3.0 Description and Comparison of Alternatives

This section describes the alternatives for storage, treatment, and disposal that are analyzed in this *Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement* (HSW EIS) as well as alternatives eliminated from detailed analysis. As required by the Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA) of 1969 (40 CFR 1500-1508), a No Action Alternative is also included.

The waste streams and facilities that are considered in this EIS were identified and described in Sections 2.1 and 2.2. Section 3.1 describes the alternatives and the development and selection of alternative groups that are analyzed in detail. Section 3.2 identifies alternatives that were not analyzed in detail. The three waste volumes, Hanford Only, Lower Bound, and Upper Bound are presented as alternative waste volume scenarios in Section 3.3. A comparison of the environmental impacts associated with each of the alternative groups is contained in Section 3.4. The major uncertainties in the EIS analysis are identified in Section 3.5. A summary of the estimated costs for the alternative groups is included in Section 3.6. The U.S. Department of Energy (DOE) preferred alternative is discussed in Section 3.7. Detailed descriptions of alternatives, assumptions, waste volumes, and waste stream flowsheets are provided in Appendixes B and C. Section 2 and the Technical Information Document (FH 2004) to support this EIS should be reviewed when additional information on a facility or waste stream is desired.

3.1 Alternatives Considered in Detail and Their Development

The CEQ regulations direct all federal agencies to use the NEPA process to identify and assess the reasonable alternatives to proposed actions that would avoid or minimize adverse effects of the proposed action on the quality of the human environment. Related CEQ guidance in the "Forty Most Asked Questions…" states that "When there are potentially a very large number of alternatives, only a reasonable number of examples, covering the full spectrum of alternatives, must be analyzed and compared in the EIS" (46 FR 18026). In considering the alternatives for this EIS it was quickly recognized that there is a very large number of combinations of the various waste streams, potential waste volumes and individual options for storage, treatment, and disposal. Therefore, the alternatives developed for this EIS were selected to represent a full spectrum of reasonable alternatives.

The individual alternatives for the proposed actions are shown in Figure 3.1. The alternatives are first subdivided into three types of action (storage, treatment, and disposal), and then further subdivided into specific alternatives for each of the waste types (LLW, MLLW, TRU waste, ILAW, and melters) as appropriate. It should be noted that no storage or treatment alternatives are shown for ILAW and melters because those activities have been, or are being, evaluated in separate NEPA reviews (DOE and Ecology 1996; 68 FR 1052). Also, no disposal alternatives are shown for TRU waste because DOE previously decided to dispose of TRU waste at the Waste Isolation Pilot Plant (WIPP; DOE 1997b). WIPP alternatives and activities are also not within the scope of this EIS. Disposal alternatives for each of the waste

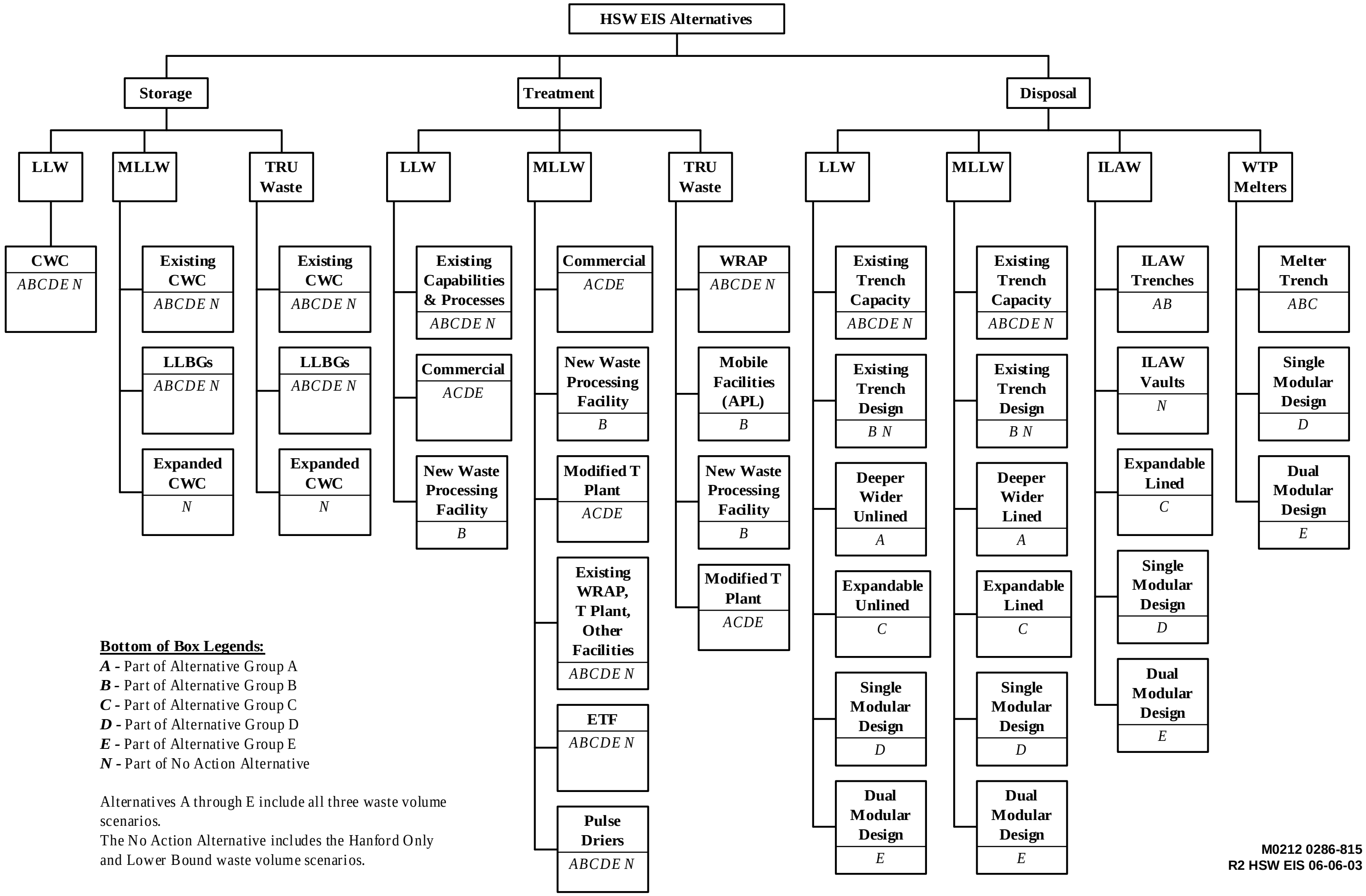


Figure 3.1. Options for HSW EIS Alternatives

types consider both independent disposal facilities for a single waste type as well as modular combined-use disposal facilities that would contain either two or four of the waste types.

It should be noted that Figure 3.1 has been simplified by considering actions where possible at the four waste type levels, rather than the 21 waste stream levels (see Figure 2.1 in Section 2). In the descriptions of the alternatives, specific actions for individual waste streams are also discussed. With the primary alternatives in Figure 3.1, alternative groups can be defined from the potential combinations of storage, treatment, and disposal alternatives for each of the waste types. However, these groupings for purposes of analysis are not intended to be restrictive in the final selection and implementation of the EIS alternatives. DOE may ultimately develop its final decisions based on a different combination of specific actions for individual waste streams.

For the analysis of potential actions, DOE has defined six representative alternatives groups from among the many possible combinations. It is necessary in the development of an alternative to specify options for each of the waste types and to include a full set of treatment, storage, and disposal activities. For the purposes of this EIS, each selected set of activities is called an alternative group, since it consists of a group of alternatives for various waste types and activities. The use of groups in the analysis is necessary because some facilities can process more than one waste type, and some impacts are only meaningful when assessed using a complete set of alternatives. The alternative groups have been identified as A, B, C, D, E, and No Action (N). Key characteristics of each of the groups are shown in the adjacent text box. Each of the alternative groups is discussed in greater detail in subsequent sections. The individual alternative actions that are used in each of the alternative groups can be noted by the corresponding letter in italics at the bottom of each box. Note that some individual alternatives are used in all alternative groups, whereas in other cases an alternative is only used in one alternative group. For Alternative Groups D and E, different potential disposal facility locations within the Hanford Central Plateau are under consideration and have been evaluated in Section 5. The specifics for the locations are discussed in their respective sections (3.1.5 and 3.1.6). The locations of the major facilities are shown in Figure 3.2.

Key Characteristics of Alternative Groups

A – Additional treatment in the modified T Plant and disposal in deeper and wider trenches.
B – Additional treatment in a new waste processing facility and disposal using existing trench designs.
C – Additional treatment in the modified T Plant and disposal in a single expandable trench for each waste type.
D – Additional treatment in the modified T Plant and disposal in a single combined-use facility containing LLW, MLLW, ILAW, and WTP melters.
E – Additional treatment in the modified T Plant and disposal in two combined-use facilities, one for LLW and MLLW, and the second for ILAW and WTP melters.
N (No Action) – Continue current practices or implement previous decisions.

Within the EIS, DOE analyzes as many as three alternative waste volume scenarios. The "Hanford Only" waste volume represents waste forecast to be received from Hanford Site generators. The "Lower Bound" waste volume is the current best estimate of the amount DOE could receive from offsite (based on past receipts) combined with the best projection of what might be generated at Hanford. The "Upper Bound" waste volume provides the highest projected offsite waste volume that could be received, along with the best projection of what might be generated at Hanford.

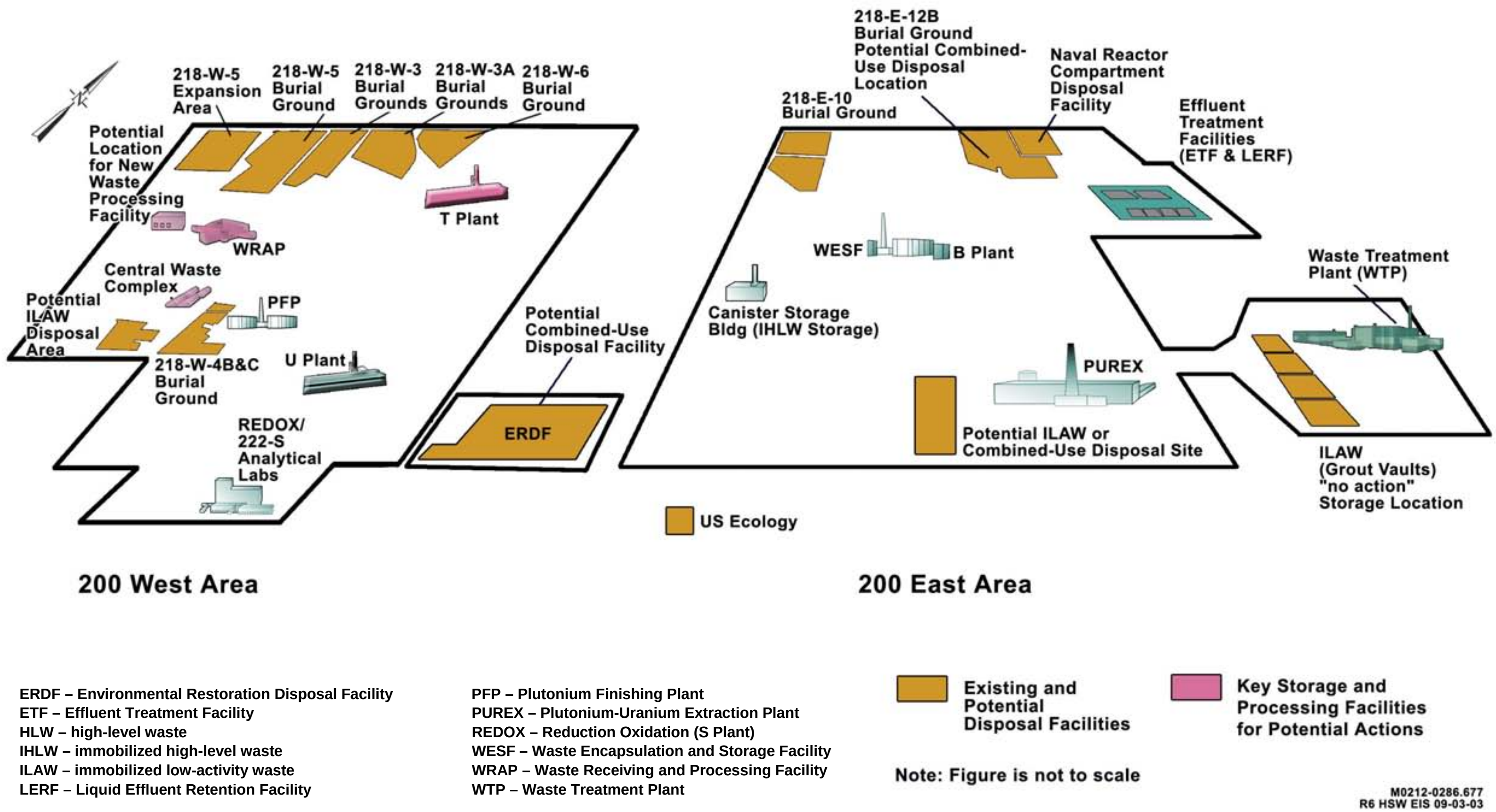


Figure 3.2. Locations of Existing and Potential Processing and Disposal Facilities on the Hanford Site

The Hanford Only waste volume excludes future offsite waste volumes entirely so the incremental impacts of receiving offsite waste could be determined. The three volumes by waste type are illustrated in Figure 3.3.

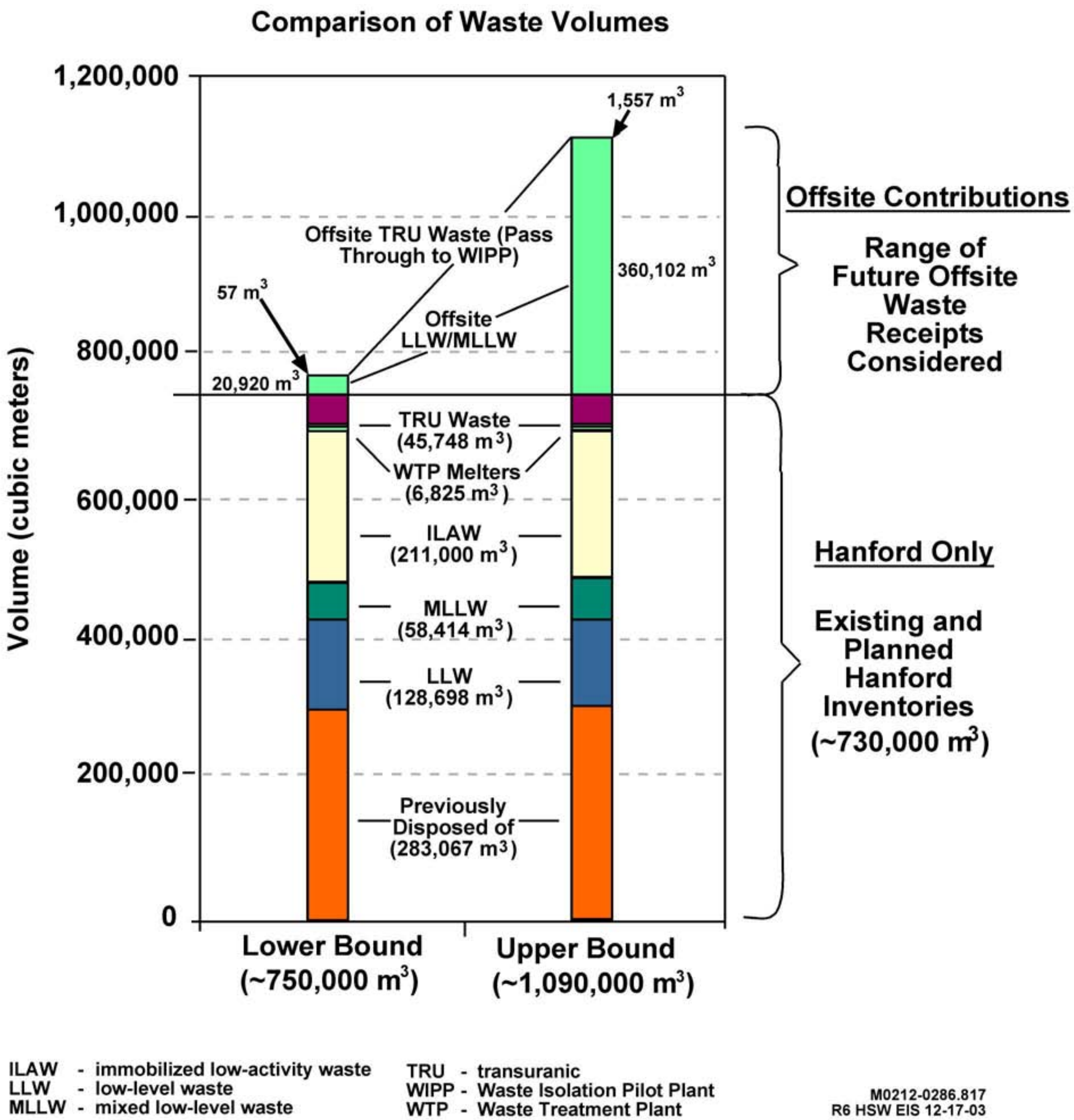


Figure 3.3. Range of Waste Volumes Considered in the HSW EIS

3.1.1 No Action Alternative

The No Action Alternative provides a baseline for comparison of the impacts from the proposed action and alternatives and is consistent with decisions reached under previous NEPA reviews. No Action thus reflects the current status quo and continued operation of existing facilities without conducting additional activities necessary to meet regulatory obligations. The No Action Alternative would only partially meet DOE's obligations under the Hanford TPA and applicable regulatory requirements. As such it represents an analytical construct to meet NEPA requirements rather than an expression of DOE's intended future actions.

Because most activities considered in the HSW EIS are ongoing operations, or have been the subject of previous decisions made under other NEPA reviews, the No Action Alternative consists of implementing the previous NEPA decisions or of continuing current solid waste management practices, consistent with CEQ guidance. The No Action Alternative for disposal of ILAW consists of the preferred alternative described previously in the Tank Waste Remediation System (TWRS) EIS (DOE and Ecology 1996). The No Action Alternative was evaluated using the Hanford Only waste volume and the Lower Bound waste volume. The ILAW volume reflects a different waste form (cullet in canisters) than that assumed for Alternative Groups A through E (monolithic vitrified waste in canisters).

3.1.1.1 Storage

In the No Action Alternative, additional CWC storage would be needed for waste that could not be treated or disposed of. Hanford's non-conforming LLW would continue to be stored in the CWC. Most MLLW would be stored at CWC due to limited treatment and disposal capacity. Likewise, melters from the WTP would be stored at CWC, because no disposal facility would be available for them. All TRU waste that cannot be processed at WRAP would be stored at CWC or the T Plant Complex. The wastes requiring storage would include non-standard containers, RH TRU waste, and PCB-commingled TRU waste. K Basin sludge would remain in storage at the T Plant Complex. Additional storage space would be constructed at CWC as needed for LLW, MLLW, melters, and TRU waste.

The existing grout vaults would be modified for storage of ILAW until disposal vaults were constructed in accordance with the TWRS EIS ROD.

3.1.1.2 Treatment

No treatment capability would be available for non-conforming LLW, and for most MLLW. Treatment of solid MLLW would be limited to the existing commercial treatment contracts and the limited existing capacity of WRAP, the T Plant Complex, and other onsite facilities. Leachate from the MLLW trenches would be collected and sent by truck to the 200 East Area Effluent Treatment Facility (ETF) for treatment. After ETF closes, leachate would be treated using a pulse drier. Solids from that treatment would be sent to the MLLW trenches for disposal or to CWC for storage after the trenches are closed. Previously treated MLLW, potentially including MLLW received from offsite generators, would be directly disposed of in the two existing regulatory-compliant (lined) MLLW trenches as long as space is available.

Processing and certification of TRU waste would continue at WRAP, the T Plant Complex, and mobile processing facilities (accelerated process lines, or APLs) to prepare existing stored and newly generated CH TRU waste packaged in standard containers for shipment to WIPP. The EIS analysis assumed that DOE would continue to operate WRAP until 2032 to perform this function. After closure of WRAP, individual generators would be responsible for certifying and shipping their own waste.

Consistent with the TWRS EIS ROD, ILAW would be processed into cullet (granular glass particles similar in size to pea gravel), and placed into containers for onsite storage in modified grout vaults that were constructed in the 1980s.

3.1.1.3 Disposal

LLW would be prepared for disposal to meet the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC, FH 2003). Cat 1 wastes would be placed directly into the LLBGs. Cat 3 and GTC3 wastes would either be disposed of in high-integrity containers (HICs) or in-trench grouted. DOE would continue the practice of building LLW disposal trenches in the LLBGs using the current trench design (unlined) as additional disposal capacity is needed. DOE would backfill the trenches with soil as their capacity is reached, but the trenches would not be capped.

Disposal of MLLW would occur only in the two existing MLLW trenches. The MLLW trenches would be capped in accordance with regulations after they are filled. An additional 66 new vaults would be constructed for ILAW disposal in the 200 East Area within 3.1 km (1.9 mi) of the existing vaults southwest of PUREX. The new vaults would contain a leachate collection system and would have an array of monitoring wells. All ILAW would be transferred to the new vaults, which would be equipped with a crane to place the containers into specific locations that would be recorded into a registry that includes container serial number, date, and position. An interim barrier containing a surface liner and an interim cover of sand and gravel totaling about 3.3 m (11 ft) thick would be placed over the containers. A regulatory-compliant barrier would be applied at closure.

3.1.2 Alternative Group A

The storage, treatment, and disposal alternatives included in Alternative Group A are described in the following sections.

3.1.2.1 Storage

Most LLW would not be stored, but would be sent directly to the LLBGs. However, some waste would be received and placed into temporary storage in CWC until it could go to WRAP for inspection. After passing inspection it would be sent on to the LLBGs. Non-conforming LLW that cannot go to disposal would be stored in CWC until it could be sent to a treatment facility. No long-term storage of LLW is expected in Alternative Group A.

Historically, MLLW has been stored in CWC and would continue to be stored there until treatment is available. In Alternative Group A, all MLLW would be treated, so no long-term storage would be needed.

TRU waste is currently stored in CWC and in the LLBGs. In Alternative Group A, all of the waste would be sent to onsite processing facilities and then to WIPP, thus eliminating any long-term onsite storage requirement.

WTP waste including the ILAW and melters would be sent directly to their respective disposal facilities. Storage of these wastes is not evaluated in this EIS.

3.1.2.2 Treatment

LLW needs to meet the HSSWAC before it can be disposed at Hanford. Most LLW does not require treatment to meet the HSSWAC. Treatment of LLW for volume reduction is not generally economically beneficial and is therefore not proposed as part of the HSW EIS alternatives. Cat 1 wastes would be placed directly into the LLBG following verification. Cat 3 and GTC3 wastes would continue to be either emplaced in HICs or in-trench grouted. For purposes of analysis, it was assumed nonconforming LLW that could not be treated onsite would be treated in a commercial treatment facility and returned to Hanford for disposal.

At Hanford, most MLLW arrives treated and ready for disposal without further treatment. Other waste streams require treatment in accordance with regulatory requirements to allow the wastes to meet the HSSWAC for onsite disposal. Six MLLW streams are evaluated in this HSW EIS, each of which involves specific treatment standards. DOE would continue to use limited existing treatment capabilities at the T Plant Complex, WRAP, and other onsite facilities as appropriate; however, most MLLW generated at Hanford would require development of new treatment capacity.

Treatment standards for CH Inorganic Solids and Debris specify treatment by macroencapsulation as demonstrated by an existing commercial contract. DOE would continue to use commercial facilities to treat most of Hanford's CH MLLW, with minimal onsite treatment in the modified T Plant Complex. CH Organic Solids and Debris require thermal treatment if such capability is available. Availability of thermal treatment technologies has been limited; however, in this Alternative Group it is assumed that the commercial facilities would become available to treat these wastes. Most Elemental Lead, which would likely be treated by macroencapsulation, and Elemental Mercury wastes, possibly treated by thermal desorption, would be sent to commercial treatment facilities. The Mixed Waste Trench Leachate would be treated in ETF, and pulse driers would be used after ETF closes. Treatment would be the same as in the No Action Alternative; however, the volume would be much higher with additional disposal trenches.

The RH and non-standard Packages of MLLW and TRU waste require new treatment and processing capabilities. In Alternative Group A, operations such as size-reduction and repackaging technologies and RH macroencapsulation capacity would be incorporated into the modified T Plant to process these waste streams.

In Alternative Group A, the CH TRU wastes from trenches, wastes currently stored in CWC, and newly generated TRU wastes in standard packages would be processed in WRAP. DOE would continue to operate WRAP until 2032 to perform this function. After closure of WRAP, individual Hanford generators would be responsible for certifying and shipping their own waste. The RH and non-standard wastes from trenches and caissons, wastes currently stored in CWC, newly generated wastes, polychlorinated biphenyl (PCB) wastes, and K Basin sludge, would be processed in a modified T Plant using a variety of technologies to package and certify the wastes for WIPP. Mobile processing facilities (APLs) would be used to supplement these existing and planned capabilities to accelerate preparation of TRU waste for shipment to WIPP.

3.1.2.3 Disposal

Alternative Group A would utilize the existing LLW trenches in the LLBG until they have been filled, and then additional disposal trenches would be constructed in the 200 West Area using a deeper, wider trench design to increase the efficiency of the disposal operations and to maintain the current focus of LLW disposal operations in the 200 West Area in accordance with the previous performance assessments for LLW disposal. Unlined deeper and wider trenches would be used after about 2005.

MLLW disposal alternatives would use the existing MLLW trenches until they have been filled and then develop deeper, wider lined trenches in the 200 East Area. Leachate from the 200 East Area disposal facilities would then be sent by truck to the ETF for treatment, and pulse driers would be used thereafter.

TRU waste would be shipped to WIPP.

The ILAW canisters would be placed into a dedicated disposal facility near PUREX in multiple lined trenches.

The large WTP melters would be taken to a dedicated lined trench near PUREX for disposal.

All of the MLLW trenches would be capped when the trenches are filled. Other LLW trenches, ILAW, and melter trenches would be closed at the end of their mission and the disposal facilities would be capped in accordance with applicable regulatory requirements with the Modified RCRA Subtitle C Barrier.

3.1.3 Alternative Group B

Alternative Group B includes activities that maximize onsite treatment of MLLW and non-conforming LLW, and which involve construction of new facilities to treat LLW, MLLW, and TRU waste. Disposal of LLW and MLLW would take place in less efficient trench configurations of existing design. Disposal of WTP melters and ILAW would use the same trench configurations as in Alternative Group A, but would occur in different locations. This combination of alternatives is expected to result in the maximum short- and long-term environmental impacts because it includes more onsite activities and new construction. Alternatives included in Alternative Group B are described as follows.

3.1.3.1 Storage

The storage alternatives for LLW, MLLW, and TRU waste are the same in Alternative Group B as in Alternative Group A.

3.1.3.2 Treatment

LLW treatment alternatives are the same as in Group A, except for the non-conforming wastes. Those wastes would be sent to an onsite New Waste Processing Facility rather than to a commercial treatment facility.

MLLW treatment would first complete the existing commercial contracts and then utilize the New Waste Processing Facility rather than using additional offsite commercial facility contracts and the modified T Plant as in Alternative Group A. Existing MLLW treatment capabilities at the T Plant Complex, WRAP, and other onsite facilities would continue to be used as appropriate.

TRU waste would be prepared for shipment to WIPP. The New Waste Processing Facility would process RH waste, waste in non-standard containers, and other wastes that would be processed at the modified T Plant under Alternative Group A. WRAP would continue operations as the main processing facility for CH TRU waste in standard containers, and TRU waste processing capacity would be increased by the use of mobile treatment facilities (APLs).

3.1.3.3 Disposal

As in Alternative A, the existing LLW trenches and existing MLLW trenches would first be utilized. Then additional facilities based on the current design for LLW trenches would be built in the 200 West Area. Additional MLLW trenches of the current design would be built in the 200 East Area. Leachate from the 200 East Area disposal facilities would then be sent by truck to the ETF for treatment, and pulse driers would be used thereafter.

The WTP melters would be disposed of in a single expandable lined trench to be built in the 200 East Area LLBGs, and the ILAW would be disposed of in multiple lined trenches to be built in the 200 West Area.

All of the mixed waste trenches would be capped with a Modified RCRA Subtitle C Barrier in accordance with applicable regulatory requirements. The rest of the LLBGs would be capped at closure.

All of the processed and certified TRU waste would be shipped to WIPP.

3.1.4 Alternative Group C

Alternative Group C activities for storage, treatment, and processing of LLW, MLLW, and TRU waste are the same as those considered in Alternative Group A. This group also includes use of existing LLW and MLLW disposal capacity before construction of new disposal facilities and appropriate closure as in Alternative Group A.

Additional disposal alternatives in Alternative Group C include: LLW disposal in the LLBGs in a single expandable unlined trench in the 200 West Area; MLLW disposal in the LLBGs in a single expandable lined trench in the 200 East Area; ILAW disposal in a single expandable lined trench near

PUREX, and melter disposal in a single expandable lined trench also near PUREX. All of the trenches would be capped with a Modified RCRA Subtitle C Barrier at closure in accordance with applicable regulatory requirements.

3.1.5 Alternative Group D

Alternatives for storage, treatment, and processing of LLW, MLLW, and TRU waste are the same as those considered in Alternative Group A. Alternative Group D considers a single lined modular combined-use facility for onsite disposal of all LLW, MLLW, ILAW, and WTP melters. This alternative group contains three subalternatives that correspond to different locations for the combined-use disposal facility. The subalternatives are denoted by subscripts. This group also includes use of existing LLW and MLLW disposal capacity before construction of new disposal facilities and appropriate closure as in Alternative Group A. The three subalternative locations for the single combined-use disposal facility are:

- Alternative Group D_1 – 200 East Area near the PUREX plant
- Alternative Group D_2 – 200 East Area LLBGs
- Alternative Group D_3 – at ERDF.

During final design a combined-use disposal facility could be configured in numerous ways. Different waste types could be disposed of in separate cells within a combined-use disposal facility, or different waste types could be disposed of in the same cell (commingled). Little interaction between the different waste types is anticipated because MLLW, ILAW, and the melters would meet applicable regulatory requirements for disposal. In addition, all waste types would need to meet the waste acceptance criteria for that disposal facility. The separate cells could be permitted under RCRA where appropriate, or the entire facility could be operated under a single regulatory program.

3.1.6 Alternative Group E

Alternatives for storage, treatment, and processing of LLW, MLLW, and TRU waste are the same as those considered in Alternative Group A. This group also includes use of existing LLW and MLLW disposal capacity before construction of new disposal facilities and appropriate closure caps as in Alternative Group A. Alternative Group E considers two onsite lined combined-use facilities, one facility for combined disposal of LLW and MLLW, and a separate facility for combined disposal of ILAW and WTP melters. Alternative Group E contains three subalternatives that correspond to different combinations of locations for the two disposal facilities. The subalternatives are denoted by subscripts. This group also includes use of existing LLW and MLLW disposal capacity before construction of new disposal facilities and appropriate closure as in Alternative Group A. The subalternative locations for the two dual-use disposal facilities are:

- Alternative Group E_1 – combined disposal of LLW and MLLW in a modular lined facility in the 200 East Area LLBGs; combined disposal of WTP melters and ILAW in a modular lined facility at ERDF;

- Alternative Group E_2 – combined disposal of LLW and MLLW in a modular lined facility near PUREX; combined disposal of WTP melters and ILAW in a modular lined facility at ERDF; and

- Alternative Group E_3 – combined disposal of LLW and MLLW in a modular lined facility at ERDF; combined disposal of WTP melters and ILAW in a modular lined facility near PUREX.

During final design a combined-use disposal facility could be configured in numerous ways. Different waste types could be disposed of in separate cells within a combined-use disposal facility, or different waste types could be disposed of in the same cell (commingled). Little interaction between the different waste types is anticipated because MLLW, ILAW, and the melters would meet applicable regulatory requirements for disposal. In addition, all waste types would need to meet the waste acceptance criteria for that disposal facility. The separate cells could be permitted under RCRA where appropriate, or the entire facility could be operated under a single regulatory program.

3.1.7 Summary Tables of Alternative Groups

To facilitate comparison and references for each of the alternative groups, Tables 3.1 and 3.2 summarize the various actions proposed as part of each group. Table 3.1 provides the treatment alternatives and Table 3.2 provides the disposal alternatives. Table 3.1 identifies the various treatment alternatives on a waste stream level and shows which individual alternatives (indicated by bullet) are included in each alternative group. The ILAW and melter waste types are not included in Table 3.1 since the treatment of ILAW and melters is part of the WTP scope. In Table 3.2 the individual disposal facility alternatives are shown for each alternative group.

3.2 Alternatives Considered but Not Evaluated in Detail

This section describes alternatives that were considered as possible methods for the management of one or more of the waste types, but were not evaluated in detail, because DOE has determined that they are not currently reasonable alternatives. The alternatives are organized by the key activity of storage, treatment, and disposal. This section also provides a qualitative discussion of the Stop Work scenario.

3.2.1 Storage Options

3.2.1.1 Storage of Waste at the Generators' Sites

Storage of waste at either the Hanford or offsite generators' sites could potentially reduce the storage requirements at CWC. However, the action alternatives do not require additional storage beyond the current CWC capacity. Storage at multiple sites would not allow DOE to take advantage of the economies of scale possible by consolidation of the wastes at CWC and would make security more difficult. Continued storage at generators' sites could be inconsistent with LDR requirements and site treatment plans. Most onsite and offsite generators do not have permitted onsite storage available and would need to increase storage capacity, which might adversely impact cleanup and closure activities.

Table 3.1. Treatment Alternatives Summary

Treatment Alternatives	Alternative Groups for Analysis					
	A	B	C	D	E	No Action
LLW – Cat 1						
None required; optional by generator	--	--	--	--	--	--
LLW – Cat 3, GTC3						
HICs or Trench Grouted	s	s	s	s	s	s
LLW – Non-Conforming						
Offsite Facility, establish new contract(s)	•		•	•	•	
New Waste Processing Facility in 200 W Area		•				
None (storage of untreated LLW)						•
MLLW – RH & Non-Standard Containers						
Modified T Plant	•		•	•	•	
New Waste Processing Facility in 200 W Area		•				
None (storage of untreated MLLW)						•
MLLW – CH Standard, Organic Solids & Debris						
Offsite Facility, complete existing commercial contract	s	s	s	s	s	s
Offsite Facility, establish new contract(s)	•		•	•	•	
New Waste Processing Facility in 200 W Area		•				
None (storage of untreated MLLW)						•
MLLW – CH Standard, Elemental Lead, Elemental Mercury						
Offsite Facility	•		•	•	•	
New Waste Processing Facility in 200 W Area		•				
None (storage of untreated MLLW)						•
MLLW – Disposal Trench Leachate						
Effluent Treatment Facility (ETF)	s	s	s	s	s	s
Pulse dryers after ETF closure	s	s	s	s	s	s
TRUW – CH Standard (retrievably stored in LLBGs & CWC, newly generated)						
WRAP	•	•	•	•	•	•
Mobile Units (APLs) in 200 W Area	•	•	•	•	•	•
TRUW – CH Non-Standard (LLBGs, CWC, newly generated), RH (LLBGs, caissons, CWC, newly generated), K Basin sludge, PCB Commingled						
Modified T Plant	•		•	•	•	
New Waste Processing Facility in 200 W Area		•				
Mobile Units (APLs) in 200 W Area	•	•	•	•	•	•
None (storage of unprocessed TRU Waste)						•

-- = Activity not included in analysis.
s = Activity included in analysis; same for all alternatives.
• = Alternative actions evaluated in analysis group.

Table 3.2. Disposal Alternatives Summary

Disposal Alternatives for New Construction[a]	Alternative Groups for Analysis									
				D			E			No Action
	A	B	C	1	2	3	1	2	3	
LLW – Cat 1, Cat 3, GTC3, Non-Conforming										
200 W LLBG – Existing design unlined trenches		•								
200 W LLBG – Deeper, wider unlined trenches	•									
200 W LLBG – Single unlined trench			•							
Near PUREX – Modular combined-use lined facility				•				•		
200 E LLBG – Modular combined-use lined facility					•		•			
ERDF – Modular combined-use lined facility						•			•	
200 W LLBG – Existing design unlined trenches, backfill only, no barrier (Cat 1, Cat 3, GTC3 LLW)										•
None (storage of non-conforming LLW)										•
Previously Buried Waste										
Install Modified RCRA Subtitle C Barrier	•	•	•	•	•	•	•	•	•	
Backfill only, no RCRA barrier										•
MLLW – treated, ready for disposal, RH & CH MLLW, Elemental Lead & Elemental Mercury, solids from MLLW leachate treatment										
200 E LLBG – Existing design lined trenches		•								
200 E LLBG – Deeper, wider lined trenches	•									
200 E LLBG – Single expandable lined trench			•							
Near PUREX – Modular combined-use lined facility				•				•		
200 E LLBG – Modular combined-use lined facility					•		•			
ERDF – Modular combined-use lined facility						•			•	
None (storage of untreated MLLW and treated MLLW in excess of existing disposal capacity)										•
TRUW – CH Standard										
Ship to Waste Isolation Pilot Plant	s	s	s	s			s			s
TRUW – CH Non-Standard, RH, K Basin sludge, PCB										
Ship to Waste Isolation Pilot Plant	•	•	•	•			•			
None (storage of unprocessed TRUW)										•

(a) In all cases, existing trench space for LLW and MLLW in the 200 W Area, LLBGs would be filled before constructing new disposal capacity. All disposal facilities would be covered with a Modified RCRA Subtitle C Barrier as filled or at closure, except as noted.

S = Activity included in analysis; same in all alternative groups.

• = Alternative actions evaluated in analysis group.

Table 3.2. (contd)

Disposal Alternatives for New Construction[(a)]	Alternative Groups for Analysis									
	A	B	C	D			E			No Action
				1	2	3	1	2	3	
WTP Melters										
Near PUREX – Single lined trench	•		•							
200 E LLBG – Single lined trench		•								
Near PUREX – Modular combined-use lined facility				•					•	
200 E LLBG – Modular combined-use lined facility					•					
ERDF – Modular combined-use lined facility						•	•	•		
None (storage)										•
ILAW										
Near PUREX – Multiple lined trenches	•									
200 W Area – Multiple lined trenches		•								
Near PUREX – Single lined trench			•							
Near PUREX – Modular combined-use lined facility				•					•	
200 E LLBG – Modular combined-use lined facility					•					
ERDF – Modular combined-use lined facility						•	•	•		
Near PUREX – Lined vault disposal facility										•

(a) In all cases, existing trench space for LLW and MLLW in the 200 W Area, LLBGs would be filled before constructing new disposal capacity. All disposal facilities would be covered with a Modified RCRA Subtitle C Barrier as filled or at closure, except as noted.

• = Alternative actions evaluated in analysis group.

3.2.1.2 Shipment of Hanford GTC3 Wastes to Other Sites for Longer-Term Storage

No GTC3 LLW is forecast to be generated at Hanford, but 1 m^3 is assumed for analysis to address future contingencies. The amount of storage required for this waste is so small in comparison with other wastes, that storage of this waste at Hanford is not expected to impact the required capacity at CWC in any of the alternatives. Shipment of GTC3 wastes from Hanford to other DOE sites would not be consistent with the WM PEIS ROD (65 FR 10061) for LLW and MLLW. The effort required to send waste to another site would be greater than the effort to store onsite. Thus, the most reasonable storage alternative for GTC3 LLW is storage in CWC.

3.2.2 Treatment Options

3.2.2.1 Use of Offsite DOE Facilities for Treatment of All Hanford Waste

The consolidation of waste management functions at designated DOE sites was a major focus of the WM PEIS (DOE 1997a). Attempts were made to identify treatment capacity at other DOE sites for Hanford wastes, but treatment capacity is limited at other DOE sites. Therefore, this is not a reasonable alternative for all Hanford waste. If DOE were able to ship wastes to other DOE sites for treatment, potential impacts would be similar to those for commercial treatment. Hanford may ship small-volume waste streams to other DOE sites in the future if specialized facilities become available. However, impacts of those shipments would be similar to those included for offsite treatment of MLLW.

3.2.2.2 Use of the Effluent Treatment Facility for Non-Conforming LLW

Much of the non-conforming LLW stream is organic-based liquid. The treatment of these liquids in the ETF was considered. However, organic-based liquids wastes are not compatible with the aqueous-based ETF treatment system.

3.2.3 Disposal Options

3.2.3.1 Use of Canyon Facilities for Disposal of Specific Wastes

An ongoing CERCLA study is considering the use of the major canyon facilities for disposal of some waste types that are included in the HSW EIS (Hanford Advisory Board 1997; Richland Environmental Restoration Project 2001). As currently envisioned, higher hazard waste such as Cat 3 LLW would be placed inside the canyons and lower activity wastes (Cat 1 LLW, for example) would be placed above and outside the canyon. Waste in the cells might be grouted in place, which would provide additional protection from intrusion as well as mitigating contaminant transport. The entire facility would then be capped with an engineered barrier. Performance monitoring of the barrier would be conducted and adjustments made as necessary. The canyons, with their thick cement walls, would provide containment of the wastes inside and retard their dispersal over the long term. The wastes outside the canyons should be as well contained as wastes placed in the LLBGs. This concept is not sufficiently well developed for detailed analysis at this time. It is being studied as part of the CERCLA process, and if pursued, would be subject to future environmental review before implementation.

3.2.3.2 Leave Retrievably Stored Transuranic Waste in the Low Level Burial Grounds

In this alternative, retrievably stored TRU waste in trenches and caissons would remain buried and would not be retrieved. Further actions could be taken to minimize environmental impacts, including the placement of a barrier over the waste to reduce the potential for further waste migration. This alternative would be attractive from an operational standpoint because it would reduce worker exposure to radioactive materials from retrieval, treatment, and transportation activities, particularly the high radiation doses from RH TRU wastes in the caissons. Modeling of this alternative indicates that it would not result in substantial radionuclide discharges to the accessible environment; however, it would not be consistent with previous NEPA decisions to retrieve the waste or with the national policy to ship TRU waste to WIPP.

3.2.3.3 Use of US Ecology Disposal Facility

The US Ecology commercial LLW disposal site is located on land leased to the State of Washington near the 200 Areas within the Hanford Site boundary and could receive some of the LLW expected to be buried in Hanford Solid Waste disposal facilities. A draft State of Washington Environmental Policy Act (SEPA) EIS for the US Ecology facility has been issued (WDOH and Ecology 2000). However, this alternative was not considered reasonable as a replacement for DOE disposal capabilities because some wastes managed by DOE could not be accepted by commercial facilities, and the Hanford infrastructure would still be necessary to manage those wastes. Disposal of DOE waste in commercial facilities would also reduce the limited capacity available for commercial waste disposal. This alternative would offer no clear environmental benefit. LLW would be disposed of on the Central Plateau in unlined trenches, and costs for disposal would be higher.

3.2.3.4 Disposal of All Hanford LLW or MLLW at Other Sites

DOE previously decided that Hanford LLW and MLLW would be disposed of at Hanford (65 FR 10061). Adequate commercial disposal capacity is not available. In view of the large volumes of waste at Hanford, the cost and number of shipments involved with shipping these wastes offsite, and the limited availability of offsite disposal capacity for certain waste types, DOE does not regard shipping the bulk of Hanford waste to other sites for disposal as a reasonable alternative.

3.2.4 Stop Work Scenario

In response to stakeholder comments DOE has included a Hanford Only scenario for waste volumes and included a qualitative discussion of a Stop Work scenario for purposes of comparison with the No Action Alternative as described in the previous section. In the Stop Work scenario, all waste management operations including storage, treatment, and disposal would be terminated. No more waste would be processed or treated, and no waste would be disposed of. This scenario would not be in conformance with DOE agreements in the TPA, applicable regulations, or previous NEPA decisions. DOE does not consider this to be a reasonable scenario. Specific actions to be taken for each waste type are noted below and then onsite and offsite impacts are briefly identified. A variation of the Stop Work scenario in which Hanford would cease disposing of LLW and MLLW onsite, but would otherwise maintain normal waste management operations, is discussed and evaluated further in Appendix M.

Under the Stop Work scenario receipt of LLW would be terminated. Hanford wastes would be stored by the generator, and no offsite wastes would be received. When generators run out of storage space their activities would have to stop also, or other disposal capacity would need to be identified. No further action would be taken to dispose of waste or to cap the burial grounds. Thus, wastes in the uncapped burial grounds would be exposed to increased water percolation and release to the groundwater.

Under the Stop Work scenario no further MLLW would be received from onsite or offsite generators. Waste would be left in storage, and no treatment of existing or future-generated wastes would occur. No disposal of additional wastes would take place and there would be no closure of the existing MLLW disposal trenches.

Under the Stop Work scenario no further TRU waste would be received from onsite or offsite activities. Generators, such as the Plutonium Finishing Plant, would be required to store waste and ultimately cease operations. There would be no retrieval of suspect TRU waste from the burial grounds. There would be no processing or certification of wastes in WRAP or other facilities, and the wastes would be stored. Waste shipments to the WIPP would cease.

In this scenario for the WTP, DOE would not have the ability to dispose of the ILAW at the Hanford Site. Because of limited storage space for ILAW, tank waste retrieval and operations at the WTP would be jeopardized.

Waste generators (onsite or offsite) would not be able to dispose of waste at Hanford and would have to make other arrangements. The majority of the wastes would require storage at the generator sites. However, storage at multiple sites would not allow DOE to take advantage of the economies of scale possible by consolidating waste management activities. Lastly, most generators are not permitted to store MLLW longer than 90 days. Most onsite and offsite generators do not have onsite storage available, and the need to increase storage capacity could impact cleanup and closure activities and increase environmental impacts at Hanford and other DOE sites.

3.3 Volumes of Waste Considered in Each Alternative

The environmental impacts of the alternatives considered in this EIS will depend in part on the volumes of each waste type managed at the Hanford Site. In order to assess the impacts of different amounts of waste, alternative waste volume scenarios have been analyzed: Hanford Only, Lower Bound, and Upper Bound.

- The **Hanford Only** waste volume consists of 1) the forecast volumes of LLW, MLLW, and TRU waste from Hanford Site generators, 2) the forecast ILAW and melter volumes from treatment of Hanford tank waste, and 3) existing onsite inventories of waste that are already in storage. The analysis also includes waste that has previously been disposed of in the LLBGs.

- The **Lower Bound** waste volume consists of 1) the Hanford Only volume, and 2) additional volumes of LLW and MLLW that are currently forecast for shipment to Hanford from offsite facilities. The Lower Bound volume for TRU waste is not substantially greater than the Hanford Only volume, and is not analyzed separately in all cases.

- The **Upper Bound** waste volume consists of 1) the Lower Bound volume, and 2) estimates of additional LLW, MLLW, and TRU waste volumes that may be received from offsite generators as a result of the WM PEIS decisions.

A comparison of the waste volumes used for the HSW EIS analyses is shown in Figure 3.3.

The summary volumes used for each waste type are presented in the following sections. Annual volumes corresponding to the total volumes shown in the tables in this section are listed in Section B.4 of Appendix B (Volume II). These volumes represent the “as-received” volume of waste. As the wastes are treated and prepared for disposal their volumes may change. The changes in volume can be noted in the processing assumptions in Section B.4 of Appendix B (Volume II) and in the flowsheets in Section B.6. A more detailed description of the development of the waste volumes for each type of waste is included in Appendix C (Volume II). The number of significant figures shown in the volume tables can exceed the accuracy of the forecasts but are maintained in the document for consistency of calculations. The radiological and chemical profiles for these waste volumes are in Section B.5 of Appendix B and Appendix F (Volume II), respectively, as well as in the Technical Information Document (FH 2004).

3.3.1 LLW Volumes

The alternatives for management of LLW have been analyzed using all three sets of volumes. Table 3.3 shows the volumes of each LLW stream included in each data set. The total LLW in the Hanford Only waste volume is 411,000 m^3. The Lower Bound and Upper Bound waste volumes represent increases of approximately 21,000 m^3 and 220,000 m^3, respectively, compared with the Hanford Only waste volume. The only additional LLW expected to be managed in the Lower Bound and Upper Bound cases are LLW Cat 1 and Cat 3.

Table 3.3. Estimated Volumes of LLW Waste Streams

Waste Streams	Hanford Only (cubic meters)[(a)]	Lower Bound (cubic meters)[(a)]	Upper Bound (cubic meters)[(a)]
Cat 1	88,792	107,883	287,130
Cat 3	39,607	41,334	60,933
GTC3	<1	<1	<1
Non-conforming	299	299	299
Previously disposed waste in LLBGs	283,067	283,067	283,067
Total[(b)]	411,765	432,584	631,429

(a) To convert to cubic feet, multiply by 35.3.
(b) Totals may not equal the sum of the waste stream volumes due to rounding.

3.3.2 MLLW Volumes

As with LLW, the alternatives for management of MLLW have been analyzed using all three sets of waste volumes. The MLLW stream volumes included in each data set are shown in Table 3.4. Slightly over 58,400 m^3 are expected to be managed in the Hanford Only case. Only a small amount of additional waste, approximately 100 m^3, is expected to be managed in the Lower Bound case. The additional volume of waste that would be managed under the Upper Bound case is approximately 140,000 m^3. It is assumed in this EIS that the additional MLLW received in the Upper Bound case would be treated prior to receipt at Hanford and that the waste would be disposed of directly. Therefore, this additional MLLW is included in the Treated and Ready for Disposal waste stream.

Table 3.4. Estimated Volumes of MLLW Waste Streams

Waste Streams[a]	Hanford Only (cubic meters)[b]	Lower Bound (cubic meters)[b]	Upper Bound (cubic meters)[b]
Treated and Ready for Disposal	28,054	28,082	168,419
RH and Non-Standard Packages	2904	2904	2904
CH Inorganic Solids and Debris	20,108	20,111	20,111
CH Organic Solids and Debris	6727	6790	6790
Elemental Lead	600	608	608
Elemental Mercury	21	21	21
Total[c]	58,414	58,515	198,852

(a) Leachate from MLLW trenches has not been included in this table because the volumes are dependent upon the selected alternative. The total volume of leachate from the MLLW trenches by alternative can be found in the flowcharts in Appendix B.
(b) To convert to cubic feet, multiply by 35.3.
(c) Totals may not equal the sum of the waste stream volumes due to rounding.

3.3.3 TRU Waste Volumes

The three sets of volumes developed for TRU waste are presented in Table 3.5. The Hanford Only waste volume is approximately 45,700 m^3. The Lower Bound waste volume is only slightly larger and includes approximately 57 m^3 from offsite generators. In the Upper Bound case, an additional 1,500 m^3 of TRU waste from offsite generators could be received for temporary storage and eventual shipment to WIPP. Because the differences between the three sets of volumes are small, environmental impacts have been evaluated for the Hanford Only and Upper Bound cases only.

Table 3.5. Estimated Volumes of TRU Waste Streams

Waste Streams	Hanford Only (cubic meters)[a]	Lower Bound (cubic meters)[a]	Upper Bound (cubic meters)[a]
Waste from trenches	14,552	14,552	14,552
Waste from caissons	23	23	23
Commingled PCB waste	80	95	95
Newly generated and existing CH standard containers	27,719	27,727	28,897
Newly generated and existing CH non-standard containers	1077	1077	1357
Newly generated and existing RH	2157	2191	2241
K Basin sludge	139	139	139
Total TRU waste[b]	45,748	45,805	47,305

(a) Convert to cubic feet, multiply by 35.3.
(b) Totals may not equal the sum of the waste stream volumes due to rounding.

3.3.4 Waste Treatment Plant Waste Volumes

Waste volumes expected from the Waste Treatment Plant are shown in Table 3.6. Because these wastes would be generated at Hanford, the Lower Bound and Upper Bound cases are not applicable. The volume of ILAW generated by the WTP, however, may vary depending on the waste form produced. For the No Action Alternative, ILAW would be produced in a cullet form and packaged in containers for retrievable disposal in vaults as outlined in the TWRS EIS for the preferred alternative (Phased Implementation). The EIS analysis assumed 140,000 containers would be required, or an equivalent volume of approximately 350,000 m^3. For the action alternatives, ILAW was assumed to be in a monolithic form, packaged in 2.6-m^3 containers for disposal in trenches. Approximately 81,000 containers would be required, or an equivalent volume of approximately 211,000 m^3 (Burbank 2002).

Table 3.6. Estimated Volumes of WTP Waste Streams Through 2046

Waste Streams	No Action (cubic meters)[a]	Action Alternatives (cubic meters)[a]
ILAW	350,000	211,000
WTP Melters	6,825	6,825
Total WTP waste	356,825	217,825
(a) To convert to cubic feet, multiply by 35.3.		

3.4 Comparison of Environmental Impacts Among the Alternatives

For purposes of comparison of the impacts among the alternatives in this section, impacts associated with alternative treatment, storage, and disposal actions for each waste type have been combined to provide a consolidated analysis of HSW management operations. These consolidated analyses are referred to as alternative groups, which were described in Section 3.1. The No Action Alternative analysis consists of activities resulting from taking no action for each waste type. This approach facilitates comparative presentation of impacts for all solid waste program operations evaluated in this EIS and is necessary where analyses are performed for facilities that are used to manage more than one type of waste. In the alternative group analyses, each of the waste types and activities necessary to manage those wastes are considered. In addition, within the analyses for each alternative group, three alternative waste volume scenarios were considered as described in Section 3.2, namely the Hanford Only, Lower Bound, and Upper Bound waste volumes.

Summary comparisons of impacts among the alternative groups during the operational period and during the long term (10,000 years) after disposal facility closure are presented in Tables 3.7 and 3.8, respectively. The environmental consequences presented in this section represent the impacts from implementing the alternatives for solid waste management described in Section 3.1.

Potential environmental impacts resulting from implementing any of the alternatives are compared in somewhat more detail in the sections that follow. Further details and the supporting analyses for the material presented in this section are provided in Section 5 and its appendixes.

Table 3.7. Summary Comparison of Potential Impacts Among the Alternatives During the Operational Period (Present to 2046)

Alternative Groups A-E – Hanford Only to Upper Bound Waste Volume [(a)]															
No Action Alternative Hanford Only to Lower Bound Waste Volume [(b)]															
	Facility Operations – Direct Radiation and Emissions to Atmosphere						Transportation								
	Normal Operations				Fatalities from Operational Accident Having Largest Consequences: Beyond-Design-Basis Earthquake at CWC[(c)]		Incident-Free	# Accidents/# Fatalities from Accidents							
	Chances of Latent Cancer Fatality: Lifetime Exposure of Maximally Exposed Individual														
Alternative	Public	Non-Involved Workers	Latent Cancer Fatalities (LCFs) Among Population within 80 km Lifetime Exposure	Latent Cancer Fatalities (LCFs) from Collective Radiation Exposure of Workers	Public	Non-Involved Workers[(e)]	Onsite, from Offsite, for Offsite Treatment, & TRU Waste to WIPP: Includes Transport-Crew, Public, and Non-Involved Workers, Fatalities[(f)]	Onsite, from Offsite, for Offsite Treat-ment, and TRU Waste to WIPP[(d)]	LLW, MLLW & TRU Waste Within Oreg. State Only[(d)]	LLW, MLLW & TRU Waste Within Wash. State Only[(d)]	TRU Waste to WIPP	Shrub-Steppe Habitat Disturbed, ha	Geologic Resources Committed (sand, gravel, silt/loam, and basalt), millions of m^3[(g)]	Diesel Fuel Committed Thousands of m^3	Cost in Billions of 2002 Dollars
Group A	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0–5/0	0/0–2/0	17/1	32	4.0-4.2	133–134	3.7–4.0
Group B	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–10	22/1-74/2	1/0–5/0	0/0–2/0	17/1	0	4.4-4.9	137–141	3.8–4.2
Group C	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0–5/0	0/0–2/0	17/1	14	3.7-4.0	66–67	3.5–3.9
Group D_1	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0–5/0	0/0–2/0	17/1	19–25	3.7-3.9	66–67	3.2–3.5
Group D_2	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0-5/0	0/0–2/0	17/1	0	3.9-4.0	66–67	3.2–3.5
Group D_3	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0-5/0	0/0–2/0	17/1	0	3.7-3.9	66–67	3.2–3.5
Group E_1	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0-5/0	0/0–2/0	17/1	0	3.7-3.8	66–67	3.4–3.8
Group E_2	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0-5/0	0/0–2/0	17/1	5–11	3.7-3.8	66–67	3.4–3.8
Group E_3	<1/million	<1/million	0 (<0.001)	0 (<0.5)	30	1	6–9	23/1-75/3	1/0-5/0	0/0–2/0	17/1	14	3.7-3.8	66–67	3.4–3.8
No Action	<1/million	<1/million	0 (<0.001)	1 (0.5)	30	1	2–2	10/0-13/0	1/0-1/0	0/0–0/0	8/0	10	2.7	189	3.5–3.5

See footnotes for this table on the next page.

Footnotes for Table 3.7

(a) For the action alternative groups, values represent the range for the Hanford Only to Upper Bound waste volume. Where a single value is given, the value applies to both Hanford Only and Upper Bound waste volumes. Values for health effects are rounded to the nearest whole number; values less than 0.5 are presented as zero.

(b) For the No Action Alternative, values represent the range for the Hanford Only to Lower Bound waste volume. Where a single value is given, the value applies to both Hanford Only and Lower Bound waste volumes. Values for health effects are rounded to the nearest whole number; values less than 0.5 are presented as zero.

(c) Unlike the action alternative groups where the risk of this accident would be over about 43 years, risk for the No Action Alternative would continue as long as waste is stored in CWC.

(d) Values are for Lower to Upper Bound waste volumes. The first value applies to the accidents and fatalities for the Lower Bound waste volume; the second value applies to the Upper Bound waste volume.

(e) The value shown is the probability of an LCF based on the calculated dose from the accident – the number of such non-involved workers is unknown, but likely would range from none to no more than 5. For the “involved” worker(s) that might be in a CWC building during such an event the consequences could range from none to several fatalities from collapse of the building.

(f) Consists of inferred fatalities from radiation exposure and vehicular emissions. In the final HSW EIS all offsite transport is addressed, including transport of TRU waste to WIPP and the entire transportation route for offsite waste sent to Hanford.

(g) As a result of refined calculations of resource needs based on the Technical Information Document (FH 2004), the need for gravel and sand, silt/loam, and basalt for action alternative groups increased by factors of approximately 1.8, 2.6, and 1.2, respectively, over those reported in the DEIS.

Table 3.8. Summary Comparison of Hypothetical Long-Term (up to 10,000 years) Impacts Among the Alternatives

Alternative Groups A-E–Hanford Only to Upper Bound Waste Volume[(a)]											
No Action Alternative–Hanford Only to Lower Bound Waste Volume[(b)]											
		Exposure to Radionuclides Via Groundwater Pathway									
	Additional Land Permanently Committed to Disposal, ha	**Maximum Annual Drinking Water Dose, millirem[(e, g)]**		**Maximum Chances in a Million of Fatality (LCF) to Lifetime Onsite Resident Gardener[(e, g)]**		**Maximum Chances in a Million of Fatality (LCF) for Lifetime Onsite Resident Gardener with Sauna/Sweat Lodge[(e, g)]**		**Fatalities (LCFs) in Populations over 10,000 years[(d)]**		**Waste Site Intruder Maximum Risk of Fatality at 100 Years After Closure[(e)]**	
Alternative		**200 Areas[(f)]**	**Near River**	**200 Areas[(f)]**	**Near River**	**200 Areas[(f)]**	**Near River**	**Tri-Cities**	**Portland**	**Drilling**	**Excavation[(h)]**
Group A	38–47	0.4	0.05	60	6	3000	200	0	0	4 in 100	Not applicable
Group B	56–80	0.4	0.04	50–60	6–7	7000–8000	200–300	0	0	4 in 100	Not applicable
Group C	20–29	0.4	0.04–0.05	60	6–7	3000	200	0	0	4 in 100	Not applicable
Group D_1	19–25	0.2	0.05	20-30	7–8	2000	200	0	0	4 in 100	Not applicable
Group D_2	19–25	0.2	0.06	30	8–9	4000	200	0	0	4 in 100	Not applicable
Group D_3	19–25	0.3–0.4	0.05	50	6–7	3000–4000	200	0	0	4 in 100	Not applicable
Group E_1	19–25	0.2	0.06	30	8–9	3000	200	0	0	4 in 100	Not applicable
Group E_2	19–25	0.2	0.04	30	5	3000	200	0	0	4 in 100	Not applicable
Group E_3	19–25	0.3–0.4	0.04	50	6	2000	200	0	0	4 in 100	Not applicable
No Action	86–95[(c)]	0.4–0.5	0.04	50–140	5	10,000–20,000	600	0	0	4 in 100	Likely fatality

(a) Where a single value is given it is essentially the same for the Hanford Only and Upper Bound waste volumes.
(b) Where a single value is given it is essentially the same for the Hanford Only and Lower Bound waste volumes.
(c) Includes additional land for long-term storage of waste that cannot be treated or processed for disposal.
(d) Zero inferred latent cancer fatalities. Assumed populations; Tri-Cities – 113,000; Portland – 510,000.
(e) Risk value given assumes that the event takes place; i.e., active institutional controls are not maintained after 100 years.
(f) Results presented are for a location within the 200 Areas having the highest radionuclide concentrations along a line of analysis 1-km downgradient from HSW disposal facilities. Sensitivity cases were also evaluated to determine the relationship of concentrations at the 1-km location to those at the waste management area or facility boundaries. The results of those analyses are presented in Volume I, Section 5.3.
(g) Differences in impacts compared with those presented in the revised draft EIS reflect additional mitigation to reduce the release and transport of contaminants resulting from assumed disposal of some forecast MLLW using higher integrity containment, such as HICs, macroencapsulation, and in-trench grouting.
(h) Excavation is not considered to be a reasonably foreseeable scenario for the action alternative groups because the depth of the barrier placed over disposal facilities at closure is greater than the depth of a typical basement excavation for a residence. The dose estimated for this scenario in the No Action Alternative likely would lead to fatality.

3.4.1 Land Use

Land permanently committed to HSW disposal includes about 130 ha (320 ac) occupied by waste previously disposed of in LLBGs. Disposal of the Hanford Only waste volume would increase land permanently committed for disposal from a low of 19 ha (47 ac) for Alternative Groups D and E, to a high of 56 ha (140 ac) for Alternative Group B (land-use values are rounded and may not add or convert exactly). Similarly, the increases for the Lower Bound waste volume would range from 20 ha (49 ac) to 59 ha (150 ac) for the same alternative groups. The increases for the Upper Bound waste volume would range from 25 ha (62 ac) to 80 ha (200 ac) for the same alternative groups. Therefore, disposal of forecast Hanford waste represents a 15- to 43-percent increase over land currently occupied in the LLBGs. Disposal of waste from other sites at the Upper Bound waste volume would increase the land area required by 4 to 13 percent over that needed for existing and forecast Hanford waste. In the No Action Alternative, the increase in land permanently committed to disposal would be about 28 ha (69 ac), which, however, does not take into account an increase in land usage of 66 ha (160 ac) for facilities committed to storage of LLW, MLLW, and TRU waste that could not be disposed of using existing capabilities. The areas of land to be committed are shown for comparison among the alternative groups in Table 3.9.[a] The analyses for land use can be found in Section 5.1.

Table 3.9. Comparison of Land Area Permanently Committed in the Various Alternatives as of 2046, ha[a]

Alternative	Hanford Only Waste Volume			Lower Bound Waste Volume			Upper Bound Waste Volume		
	LLW & MLLW Increase	ILAW Increase	Total Land Committed[b]	LLW & MLLW Increase	ILAW Increase	Total Land Committed[b]	LLW & MLLW Increase	ILAW Increase	Total Land Committed[b]
Alternative Group A	12	26	**169**	13	26	**170**	21	26	**178**
Alternative Group B	30	26	**187**	33	26	**189**	54	26	**210**
Alternative Group C	12	8	**151**	13	8	**152**	21	8	**160**
Alternative Groups D & E	11	8	**150**	12	8	**150**	17	8	**155**
No Action Alternative	17	10	**273**[c]	19	10	**275**[c]	Not applicable		

(a) One hectare (ha) = about 2.5 acre (ac). Values may not add exactly due to rounding.
(b) Includes 130 ha already committed for HSW previously disposed of in the LLBGs.
(c) Includes 116 ha for storage of waste in CWC buildings.

(a) Land committed represents land within which waste would be emplaced. It is assumed that buffer zones would be maintained around these waste disposal sites consistent with the Hanford Comprehensive Land-Use Plan Environmental Impact Statement Record of Decision (64 FR 61615).

Land occupied by existing treatment and storage facilities amounts to 127 ha (314 ac), which would not require expansion under any of the action alternatives except Alternative Group B. Construction of a new waste processing facility would add 4 ha (10 ac) to the total for that alternative group. At most, total land use for solid waste operations, including treatment, storage, and disposal facilities, would be about 4 percent of the 200 Area Industrial-Exclusive zone.

3.4.2 Air Quality

Air quality impacts are based on estimated concentrations of criteria pollutants: particulate matter (PM_{10}), sulfur dioxide (SO_2), carbon monoxide (CO), and nitrogen dioxide (NO_2) at points of public occupancy. Table 3.10 presents the largest potential impacts calculated for each alternative group in comparison to air quality standards. Air quality impacts for obtaining capping materials are presented separately following the table. Impacts from releases of radioactive material and chemicals to the atmosphere are addressed in Section 3.4.11 and 5.11, Human Health and Safety.

Maximum air quality impacts from operating the Area C borrow pit would amount to 14 percent of the 24-Hour Standard for PM_{10}, 26 percent of the 1-Hour Standard for SO_2, 36 percent for the 8-Hour Standard for CO, and 0.16 percent of the Annual Standard for NO_2. These impacts would be common to all alternatives.

For the most part, the impacts on air quality are essentially the same for all alternatives. An exception is Alternative Group B where the impacts for some pollutants are below standard values, but noticeably higher than for the other alternatives due to the increased excavation required for construction of disposal trenches.

Table 3.10. Comparison Among the Alternative Groups of Estimated Criteria-Pollutant Impact Maximums for Solid Waste Operations in the 200 Areas, Percent of Air Quality Standards[(a)]

Alternative	Hanford Only and Lower Bound Waste Volumes				Upper Bound Waste Volume			
	24-Hour PM_{10}	1-Hour SO_2	8-Hour CO	Annual NO_2	24-Hour PM_{10}	1-Hour SO_2	8-Hour CO	Annual NO_2
Alternative Group A	46	8.1	4.7	0.72	49	9.8	5.9	0.80
Alternative Group B	47	13	8.0	1.0	60	18	11	1.1
Alternative Group C	40	7.9	4.6	0.77	41	8.0	4.7	0.77
Alternative Group D	41	8.4	5.0	0.79	41	8.4	5.0	0.85
Alternative Group E	40	9.3	5.3	0.89	41	9.5	5.3	0.89
No Action Alternative	38	8.6	4.6	0.85	Not applicable			
(a) (24-Hour PM_{10} = 150 $\mu g/m^3$, 1-Hour SO_2 = 1,000 $\mu g/m^3$, 8-Hour CO = 10,000 $\mu g/m^3$, Annual NO_2 = 100 $\mu g/m^3$).								

3.4.3 Water Quality

As a result of wastewater management activities during past Hanford Site operations, groundwater beneath the 200 Areas has been contaminated with radionuclides and non-radioactive chemicals. The contaminants emanating from the 200 Areas are moving toward the Columbia River. None of these contaminants is thought to have originated from existing LLBGs or other waste management facilities being considered in the HSW EIS. Uncertainties regarding levels of chemicals previously disposed of in LLBGs are discussed in Section 3.5.

One benchmark measure of water quality for purposes of comparison among the alternative groups is taken as the percentage of maximum contaminant levels (MCLs)[(a)] in groundwater. The percentage of MCLs is calculated for hypothetical wells intercepting maximum combined concentrations of radionuclides in predicted plumes along several lines of analysis (LOA) downgradient from the HSW disposal facilities. These lines of analysis were positioned at a distance to capture contributions from all HSW disposal facilities within the 200 West Area, the 200 East Area, and at the ERDF. The 200 East Area results include possible contributions from upgradient sources at the 200 West Area and ERDF. The specific lines of analysis considered in this assessment are as follows:

- a line of analysis 1 km downgradient from waste disposed of in the 200 West Area LLBGs or the ILAW waste disposal facility near CWC (referred to as the 200 West LOA in Section 5.3 and in Volume II, Appendix G).

- a line of analysis about 1 km downgradient to the northwest from the 200 East LLBGs (referred to as the 200 East NW LOA in Section 5.3 and in Volume II, Appendix G). This LOA was used to evaluate concentrations in groundwater migrating northwest of the 200 East Area.

- a line of analysis about 1 km downgradient to the southeast from a new disposal facility near the PUREX Plant (referred to as the 200 East SE LOA in Section 5.3 and in Volume II, Appendix G). This LOA was used to evaluate concentrations in groundwater migrating southwest of the 200 East Area.

- a line of analysis about 1 km downgradient from the ERDF location (referred to as the ERDF LOA in Section 5.3 and in Volume II, Appendix G).

- a line of analysis along the Columbia River (referred to as the Columbia River LOA in Section 5.3 and in Volume II, Appendix G).

The highest percentages of MCLs together with the time of occurrence are given in Table 3.11 for the period ending about 10,200 A.D. In that time period technetium-99 and iodine-129 are the principal contaminants of interest. After about 10,200 A.D. uranium begins to dominate as the principal contaminant in groundwater. The highest percentages of the MCL for uranium are given in Table 3.12.

(a) Maximum contaminant levels (MCLs), defined in 40 CFR 141, apply to public drinking water supplies. Although groundwater downgradient of Hanford Solid Waste disposal sites currently is not a source for public drinking water, the MCLs provide a useful benchmark against which to compare estimated contaminant levels.

Table 3.11. Highest Percentage of Maximum Contaminant Levels to the Year 12,050 A.D.[(a,b)]

Hanford Only Waste Volume																				
Alternative	200 W Well Location				ERDF Well Location				200E NW Well Location				200 E SE Well Location				River Well Location			
	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD	**I-129**	**Tc-99**	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD
Group A	56	1	**57**	2330	Not applicable				52	0.3	**52**	2170	2	2	**4**	12,050	6	2	**8**	2320
Group B	56	1	**57**	2330					52	0.3	**52**	2170	Not applicable				6	2	**8**	2320
Group C	56	1	**57**	2330					52	0.3	**52**	2170	2	2	**4**	12,050	6	2	**8**	2320
Group D_1	56	1	**57**	2330					52	0.3	**52**	2170	26	14	**40**	3500	6	4	**10**	2320
Group D_2	56	1	**57**	2330					52	0.3	**52**	2170	Not applicable				7	5	**12**	3730
Group D_3	56	1	**57**	2330	41	27	**68**	3860	52	0.3	**52**	2170					6	3	**9**	2320
Group E_1	56	1	**57**	2330	5	7	**12**	12,050	52	0.3	**52**	2170					7	5	**12**	3720
Group E_2	56	1	**57**	2330	5	7	**12**	12,050	52	0.3	**52**	2170	28	18	**46**	3500	6	3	**9**	2320
Group E_3	56	1	**57**	2330	40	27	**67**	3860	52	0.3	**52**	2170	2	2	**4**	12,050	6	3	**8**	2320
No Action	58	1	**59**	2330	Not applicable				52	0.3	**52**	2170	2	2	**4**	12,050	8	0.2	**8**	2330
Upper Bound Waste Volume																				
Alternative	200 W Well Location				ERDF Well Location				200E NW Well Location				200 E SE Well Location				River Well Location			
	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD	I-129	Tc-99	**Total**	Yr AD
Group A	56	1	**57**	2330	Not applicable				52	0.3	**52**	2170	2	2	**4**	12,050	6	2	**8**	2320
Group B	56	1	**57**	2330					52	0.3	**52**	2170	Not applicable				7	2	**9**	3560
Group C	56	1	**57**	2330					52	0.3	**52**	2170	2	2	**4**	12,050	6	4	**10**	2320
Group D_1	56	1	**57**	2330					52	0.3	**52**	2170	26	15	**41**	3500	6	5	**11**	2320
Group D_2	56	1	**57**	2330					52	0.3	**52**	2170	Not applicable				7	5	**12**	3700
Group D_3	56	1	**57**	2330	41	28	**69**	3860	52	0.3	**52**	2170					6	4	**10**	2320
Group E_1	56	1	**57**	2330	5	7	**12**	12,050	52	0.3	**52**	2170					7	5	**12**	3690
Group E_2	56	1	**57**	2330	5	7	**12**	12,050	52	0.3	**52**	2170	28	19	**47**	3500	6	3	**9**	2320
Group E_3	56	1	**57**	2330	41	28	**69**	3860	52	0.3	**52**	2170	2	2	**4**	12,050	6	4	**10**	2320
No Action	Not applicable																			

(a) MCL for Tc-99 is 900 pCi/L; MCL for I-129 is 1 pCi/L.
(b) Due to rounding, some of the total values do not add exactly.

Table 3.12. Highest Percentage of Maximum Contaminant Levels from 10,200 to 12,050 A.D. – All Due to Uranium[(a)]

<table>
<tr><th></th><th colspan="5">Hanford Only Waste Volume</th><th colspan="5">Upper Bound Waste Volume</th></tr>
<tr><th></th><th>200 W Well</th><th>ERDF Well</th><th>200 E NW Well</th><th>200 E SE Well</th><th>River Well</th><th>200 W Well</th><th>ERDF Well</th><th>200 E NW Well</th><th>200 E SE Well</th><th>River Well</th></tr>
<tr><th>Alternative</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th><th>%</th></tr>
<tr><td>Group A</td><td><0.1</td><td rowspan="5">NA</td><td>0.2</td><td>1</td><td><0.1</td><td><0.1</td><td rowspan="5">NA</td><td>0.3</td><td>1</td><td><0.1</td></tr>
<tr><td>Group B</td><td>3</td><td>3</td><td>NA</td><td><0.1</td><td>4</td><td>3</td><td>NA</td><td>0.1</td></tr>
<tr><td>Group C</td><td><0.1</td><td>0.2</td><td>1</td><td><0.1</td><td><0.1</td><td>0.3</td><td>1</td><td><0.1</td></tr>
<tr><td>Group D$_1$</td><td><0.1</td><td>0.1</td><td>1</td><td><0.1</td><td>0.1</td><td>0.2</td><td>1</td><td><0.1</td></tr>
<tr><td>Group D$_2$</td><td><0.1</td><td>1</td><td rowspan="3">NA</td><td><0.1</td><td>0.1</td><td>1</td><td rowspan="3">NA</td><td><0.1</td></tr>
<tr><td>Group D$_3$</td><td><0.1</td><td>4</td><td>0.1</td><td><0.1</td><td>0.1</td><td>4</td><td>0.2</td><td><0.1</td></tr>
<tr><td>Group E$_1$</td><td><0.1</td><td>4</td><td>0.3</td><td><0.1</td><td>0.1</td><td>4</td><td>0.6</td><td><0.1</td></tr>
<tr><td>Group E$_2$</td><td><0.1</td><td>4</td><td>0.1</td><td>0.2</td><td><0.1</td><td>0.1</td><td>4</td><td>0.2</td><td>0.3</td><td><0.1</td></tr>
<tr><td>Group E$_3$</td><td><0.1</td><td><0.1</td><td>0.1</td><td>1</td><td><0.1</td><td>0.1</td><td><0.1</td><td>0.2</td><td>1</td><td><0.1</td></tr>
<tr><td>No Action</td><td><0.1</td><td>NA</td><td>5</td><td>1</td><td>0.3</td><td colspan="5">Not applicable</td></tr>
<tr><td colspan="11">(a) MCL for uranium is 30 micrograms per liter.</td></tr>
</table>

Under all the alternative groups (including the No Action Alternative), the highest potential impacts to groundwater quality were estimated from releases of long-lived technetium-99, iodine-129, and uranium isotopes. Using the sum-of-fractions method, the total concentrations of technetium-99 and iodine-129, when combined, would reach a maximum of 69 percent of the benchmark drinking water standard in the 200 Areas for Alternative Groups D_3 and E_3 at the ERDF 1-kilometer line of analysis for the Upper Bound waste volume in about the year 3900 A.D. Combined technetium-99 and iodine-129 concentrations would be even further below benchmark standards by the time they reached the Columbia River line of analysis for all alternative groups (including the No Action Alternative). For the No Action Alternative, uranium concentrations reached up to about 5 percent of the benchmark standard at the 200 East Area line of analysis about 10,000 years after closure. None of the alternatives would result in concentrations of uranium exceeding 0.3 percent of the benchmark standard at the river line of analysis.

The reduction in impacts associated with groundwater as presented in this FEIS compared with those presented in the revised draft HSW EIS reflect additional mitigation to reduce the release and transport of contaminants, resulting from a greater amount of MLLW assumed to be disposed of in higher integrity containment, such as HICs, macroencapsulation, or in-trench grouting. Most variation in groundwater radionuclide concentrations among the alternative groups resulted from different proposed configurations and locations for new disposal facilities, and there were essentially no differences between the Hanford Only and Upper Bound waste volumes.

LLW disposed of before October 1987 may contain hazardous chemical constituents, but no specific requirements existed to account for or report the content of hazardous chemical constituents in this category of LLW. As a consequence, analysis of these constituents and estimated impacts based on the limited amount of information on estimated inventories and waste disposal locations would be subject to greater uncertainty at this time. (Additional discussion on uncertainties is presented in Section 3.5.) A screening evaluation of hazardous chemicals potentially disposed of before October 1987 in the Low Level Burial Grounds did not identify any chemicals that would be likely to exceed the 40 CFR 141 maximum contaminant levels over the period of analysis. Wastes containing hazardous chemicals disposed of after October 1987 would have been treated according to regulatory requirements, and they are not expected to present a substantial risk for groundwater contamination.

Another measure of water quality for purposes of comparing the alternatives is taken as the annual dose to an individual from drinking 2 liters per day of groundwater from hypothetical wells located along the lines of analysis described in this section. As a benchmark, the estimated doses are compared with the 4 millirem-per-year standard for public drinking water systems operated by DOE (DOE 1993), although groundwater beneath the Hanford Site is not currently used as a source for public drinking water. These doses are based on inventories by activity presented in Appendix B, groundwater transport analysis as described in Section 5.3 and Volume II, Appendix G, and dose conversion factors based on Federal Guidance Reports 11 and 12 (Eckerman et al. 1988; Eckerman and Ryman 1993), details of which are presented in Volume II, Appendix F. The latter are presented in plots of maximum annual drinking water dose as a function of time in Figures 3.4 through 3.8.[a] Doses calculated using this method do not correspond exactly to the 4-mrem/yr whole body or maximum organ doses used to calculate MCLs in 40 CFR 141.

Estimated peak doses from drinking groundwater containing combined radionuclide concentrations at 1 kilometer from the Hanford solid waste disposal facilities, for any of the alternatives and waste volumes disposed of, would fall below 1 millirem per year over the 10,000-year period of analysis. The corresponding doses estimated adjacent to the Columbia River would be less than 0.1 millirem per year for the period of analysis. The current drinking water dose at the Richland Municipal Water Intake is about 0.1 mrem/yr. The additional dose from HSW was determined to be less than 0.00001 mrem/yr over the 10,000-year period of analysis. Results from modeling indicate potential increases in the dose near the end of the 10,000-year period because of the arrival of uranium in groundwater.

(a) The period of analysis is 10,000 years after 2046, and the plots would end at 12,046; however, the plots are constrained by the software to the next whole millennium.

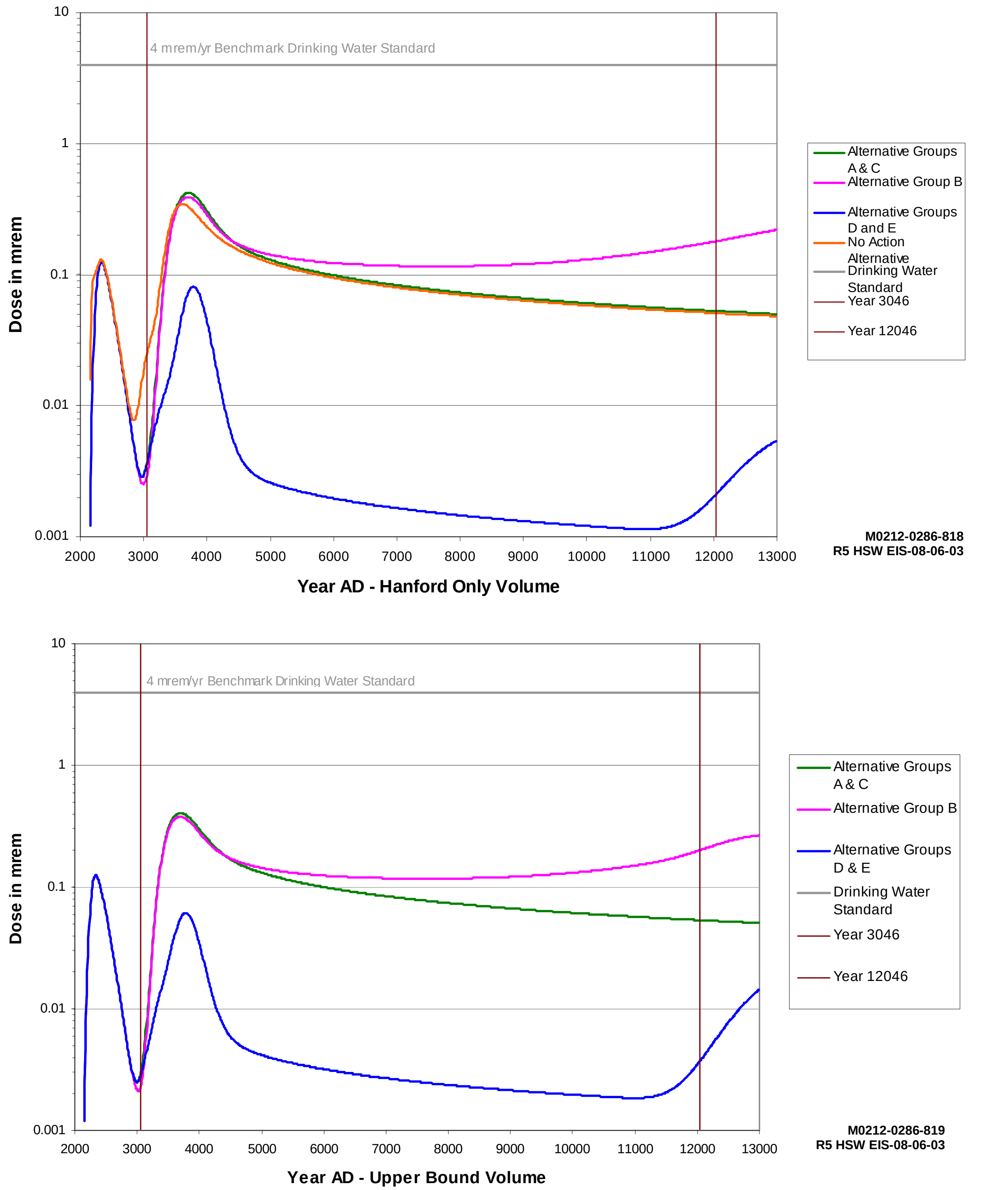
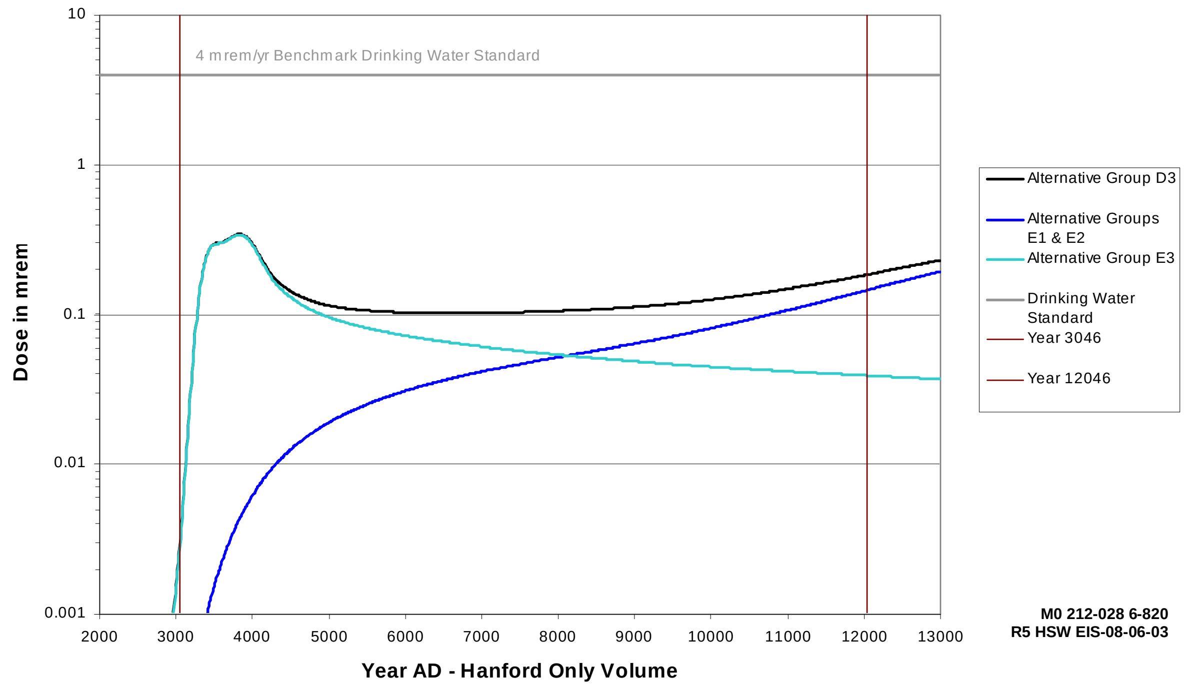


Figure 3.4. Hypothetical Annual Dose from Drinking Water Containing Maximum Concentrations of Radionuclides in Groundwater at 1 km Downgradient from the 200 West Area Disposal Facilities as a Function of Calendar Year – Hanford Only and Upper Bound Waste Volumes



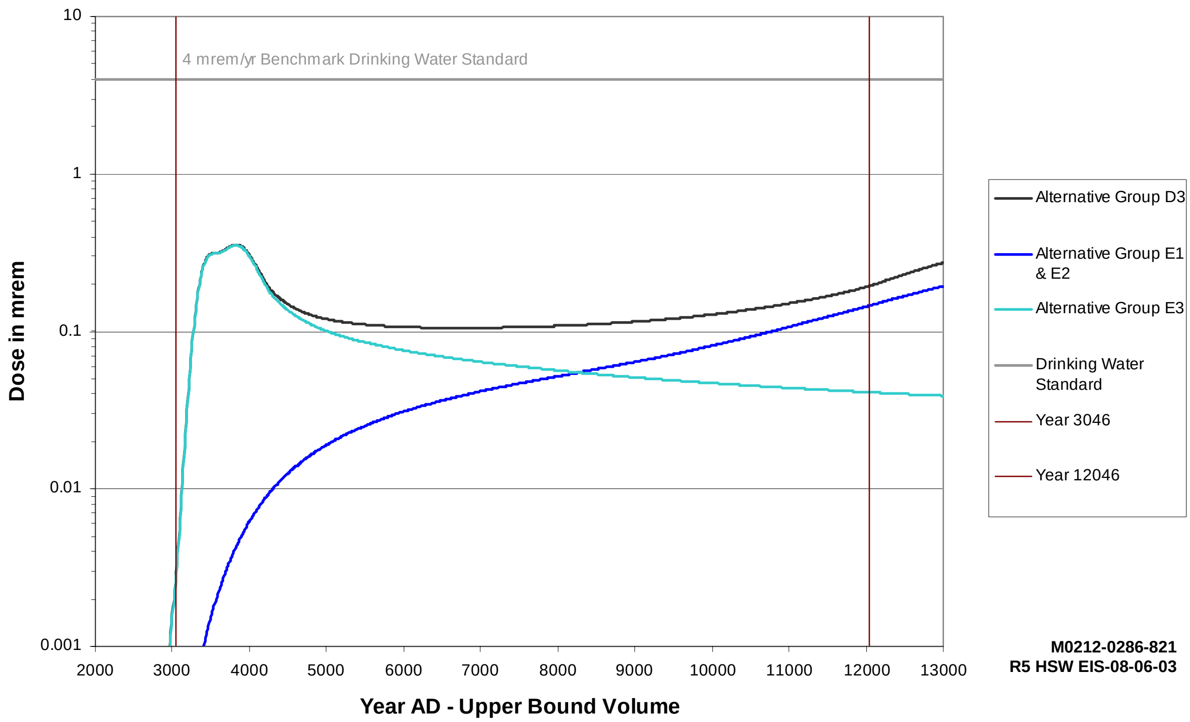


Figure 3.5. Hypothetical Annual Dose from Drinking Water Containing Maximum Concentrations of Radionuclides in Groundwater at 1 km Downgradient from ERDF as a Function of Calendar Year – Hanford Only and Upper Bound Waste Volumes

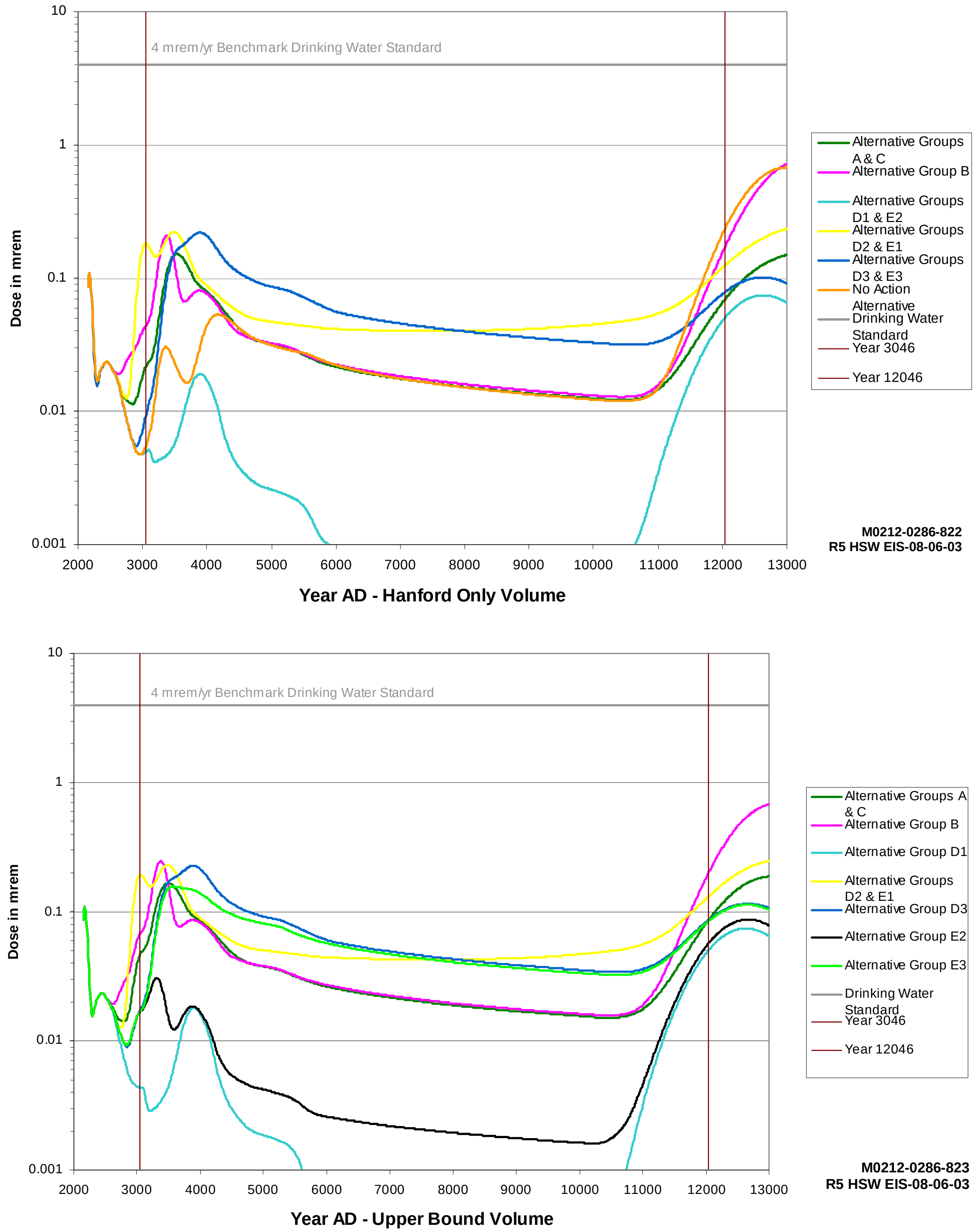
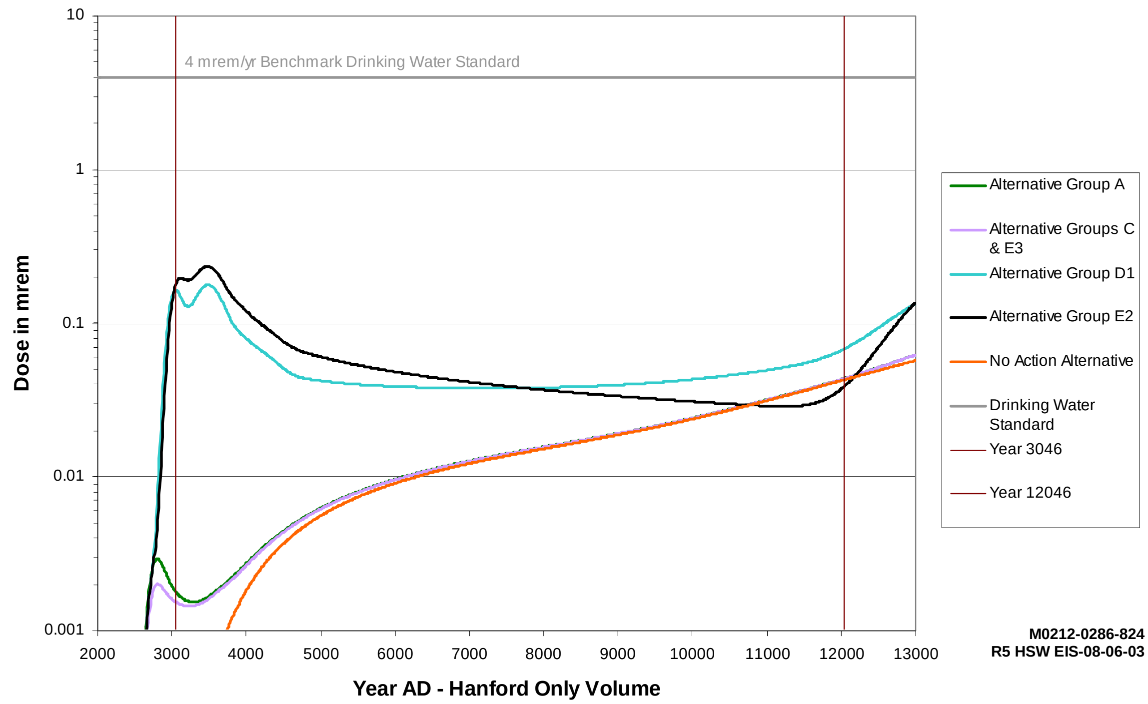


Figure 3.6. Hypothetical Annual Dose from Drinking Water Containing Maximum Concentrations of Radionuclides in Groundwater at 1 km Northwest Downgradient from the 200 East Area as Disposal Facilities as Function of Calendar Year – Hanford Only and Upper Bound Waste Volumes



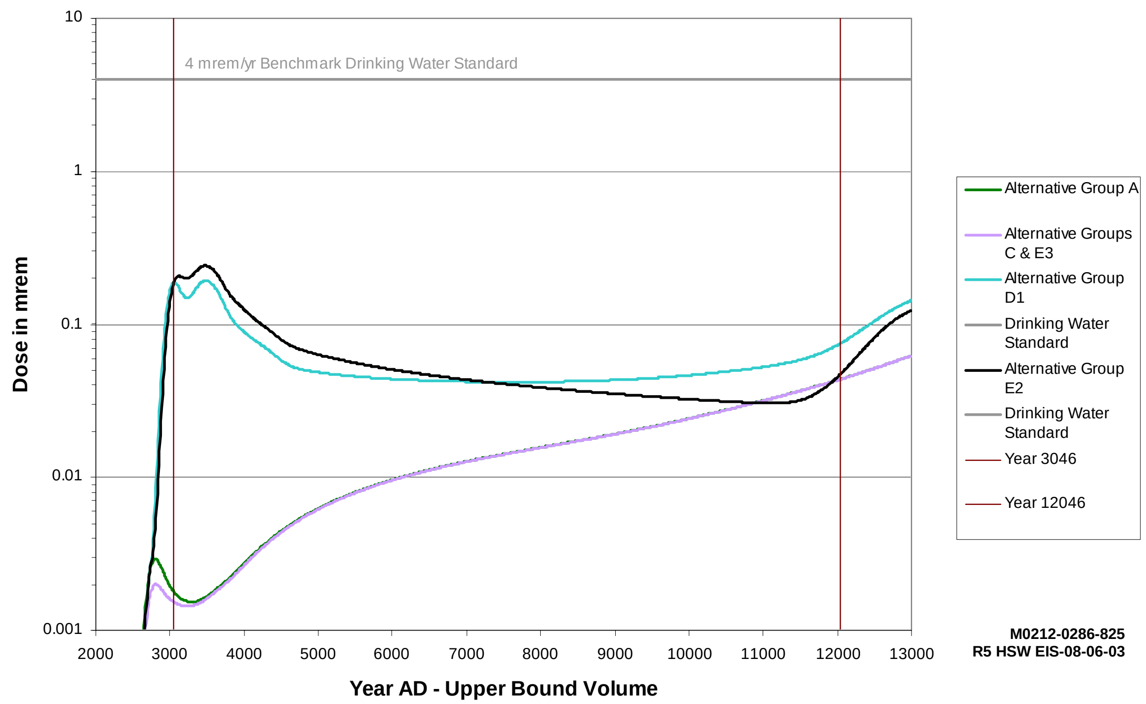
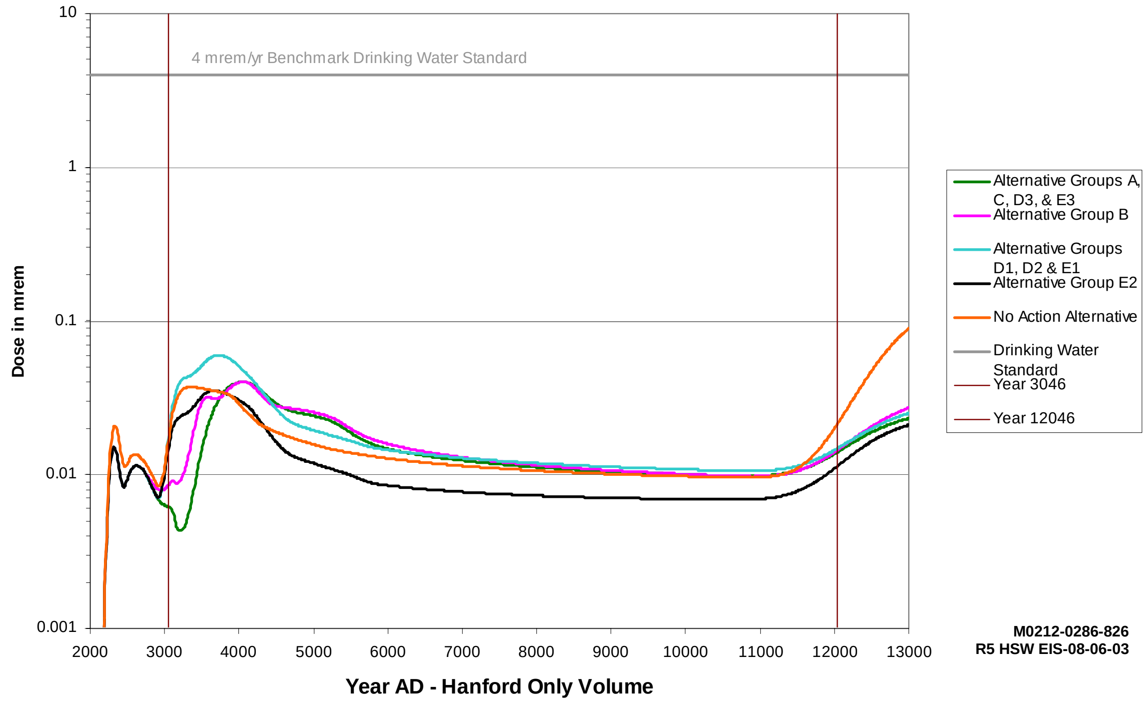


Figure 3.7. Hypothetical Annual Dose from Drinking Water Containing Maximum Concentrations of Radionuclides in Groundwater at 1 km Downgradient Southeast from the 200 East Area Disposal Facilities as a Function of Calendar Year – Hanford Only and Upper Bound Waste Volumes



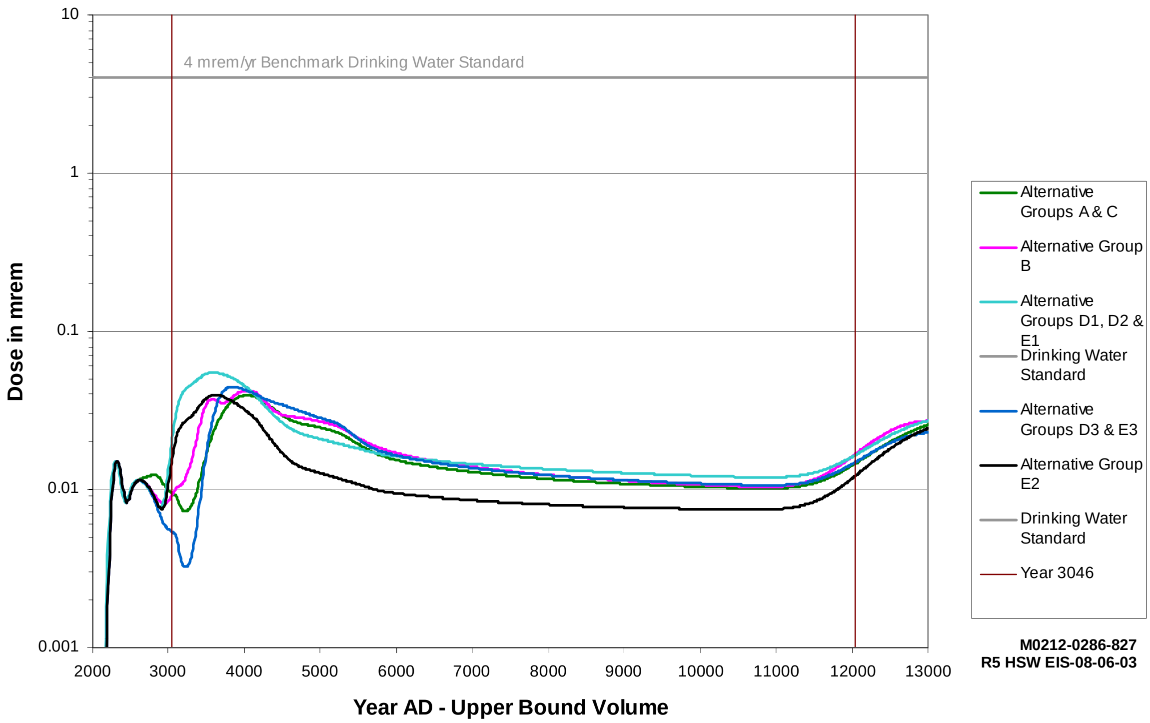


Figure 3.8. Hypothetical Annual Dose from Drinking Water Containing Maximum Concentrations of Radionuclides in Groundwater Near the Columbia River as a Function of Calendar Year – Hanford Only and Upper Bound Waste Volumes

3.4.4 Geologic Resources

Although large quantities of gravel, silt/loam, and basalt would be needed for capping waste disposal facilities upon closure, these resources are readily available in the Area C borrow pit. A comparison among the alternatives of quantities that would be needed is shown in Table 3.13. As a result of refined calculation of resource needs based on the Technical Information Document (FH 2004), the need for gravel and sand, salt/loam, and basalt for action alternative groups increased by factors of approximately, 1.8, 2.6, and 1.2, respectively, over those reported in the revised draft HSW EIS.

Table 3.13. Comparison of Commitments of Geologic Resources, Millions of m^3[(a)]

Alternative	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume
Alternative Group A	4.0	4.0	4.2
Alternative Group B	4.4	4.5	4.9
Alternative Group C	3.7	3.8	4.0
Alternative Groups D_1 and D_3	3.7	3.8	3.9
Alternative Group D_2	3.9	3.9	4.0
Alternative Group E	3.7	3.7	3.8
No Action Alternative	2.7	2.7	Not applicable

(a) 1 m^3 = about 1.3 yd^3.

3.4.5 Ecological Resources

Impacts on ecological resources, other than disturbance of shrub-steppe habitat, were determined to be low and sufficiently similar among the alternative groups (including the No Action Alternative) that they would not be expected to be an important discriminator in the alternative selection process. Disturbance of shrub-steppe habitat would be related to alternative groups making use of the near-PUREX disposal facility, which is in an area that was not burned over in the 24 Command Fire of June 2000. There, the area of disturbance ranged from zero in the case of Alternative Groups B, D_2, D_3, and E_1 to 32 ha (79 ac) for Alternative Group A. Other alternative groups and the No Action Alternative were intermediate with 5 to 25 ha (12 to 62 ac) of disturbance depending on the waste volume disposed of (see Table 3.7). Conclusions regarding potential impacts on terrestrial biota at the disposal facility near PUREX were based on spring/summer surveys conducted from 1998 to 2002. Conclusions regarding potential impacts on aquatic and riparian biota near and in the Columbia River were based on an ecological risk assessment of potential future releases from waste sites through groundwater to the river. Details of the analysis are presented in Section 5.5 with additional information in Volume II, Appendix I.

3.4.6 Socioeconomics and Environmental Justice

Implementation of any of the HSW EIS alternative groups (including the No Action Alternative) would have small and barely differentiable impacts on local socioeconomic infrastructure, including housing, schools, medical support, and transportation. Details of the analysis are presented in Section 5.6. No particular distinction was made among any of the alternatives for impacts on environmental justice (see Section 5.13).

3.4.7 Cultural, Aesthetic, and Scenic Resources

The principal potential for impacts on cultural resources in implementing any of the alternative groups (including the No Action Alternative) would be associated with disturbance of the surface and near surface portions of the Area C borrow pit. Although archeological sites might be found in Area C, a recent field reconnaissance failed to reveal any archeological sites or artifacts on the surface. Because construction would be halted in the event that an artifact of possible cultural significance is found and will remain so until a professional evaluation is made, it is unlikely that impacts to cultural resources would be an important discriminator among the alternatives. Details of the analysis are presented in Sections 5.7 and Volume II, Appendix K.

No particular distinction was made among any of the alternative groups for impacts on aesthetic and scenic resources; the most noticeable change would be the potential impact on the viewshed from nearby prominences as a result of obtaining capping materials from Area C (see Section 5.12).

3.4.8 Transportation

The measure of impacts from transportation for comparison among the alternatives was taken as the number of fatalities resulting from transport of wastes and construction materials. Those impacts include offsite transport of some MLLW for treatment at the Oak Ridge Reservation in Alternative Groups A, C, D, and E. MLLW treatment would be performed onsite in Alternative Group B. The values for the Hanford Only waste volume are presented in Table 3.14. Details of the transportation analysis are presented in Section 5.8 and Volume II, Appendix H.

Transport of wastes from offsite is the same for all alternative groups. The potential impacts of offsite transportation previously were evaluated in the WM PEIS and the WIPP SEIS-II (DOE 1997a and DOE 1997b, respectively). However, impacts of transporting waste from offsite to the Hanford Site were re-evaluated for the final HSW EIS using updated codes and the year 2000 Census data. Impacts of nationwide transport of wastes are presented in Table 3.7, Section 5.8, and Volume II, Appendix H. A comparison of results of the transportation analyses from the WM PEIS, the WIPP SEIS-II, and the final HSW EIS are presented in Section H.9 of Appendix H in Volume II.

Potential impacts within the states of Oregon and Washington that might occur from shipping waste to and from the Hanford Site were analyzed and are summarized in Table 3.15. As shown in the table, transport of waste from offsite generators and transport of Hanford TRU waste to WIPP might result in one accident in Oregon and none in Washington for the Lower Bound waste volume and five accidents in Oregon and two in Washington for the Upper Bound waste volume. One accident fatality might result during transport through Oregon and Washington for the Upper Bound waste volume.

Transport of TRU waste to WIPP for Alternative Groups A through E might result in 17 accidents and 1 fatality; for the No Action Alternative, 8 accidents and no fatalities.

Table 3.14. Summary Comparison of Potential Radiological and Non-Radiological Transportation Impacts – Hanford Only Waste Volumes (excluding TRU waste sent to WIPP)

Alternative	Radiological			Non-Radiological		
	Incident-Free		Accidents			
	Crew – Fatalities	Public – Fatalities	Accidents Fatalities	Number of Accidents	Accident Fatalities	Emissions Fatalities
Alternative Groups A, C, D, and E[(a)]	**0** (0.038)	**0** (0.25)	**0** (1.3E-5)	**3** (2.6)	**0** (0.084)	**0** (0.18)
Alternative Group B[(b)]	**0** (0.064)	**1** (0.77)	**0** (1.0E-5)	**2** (1.6)	**0** (0.068)	**0** (0.078)
No Action Alternative[(c)]	**0** (0.012)	**0** (0.093)	**0** (1.2E-5)	**1** (1.2)	**0** (0.050)	**0** (0.047)

Note: Public includes non-involved workers. Numbers in parentheses are the calculated values. Accidents and fatalities occur as whole numbers and calculated values are rounded to whole numbers.

(a) The impacts in these Alternative Groups are for the Hanford Only waste volume case. The differences between this case and the Upper and Lower Bound waste volume case of additional offsite-generated waste are shown in Table 3.15, for Oregon and Washington only. Impacts of nationwide transport of wastes are presented in Table 3.7, Section 5.8, and Appendix H.

(b) Offsite shipments for waste treatment are minimal in Alternative Group B for all waste volume cases.

(c) There are no offsite shipments for waste treatment associated with the No Action Alternative.

Table 3.15. Potential Impacts in Oregon and Washington by State from Shipments of Solid Wastes to and from Hanford[(a)]

Waste Volume/Alternative	Radiological Impacts, LCFs			Non-Radiological Impacts		
	Routine Transport		Accidents			
	Worker	Public	Public	Number of Accidents	Number of Fatalities	Emissions LCFs
Oregon State						
Hanford Only – Action Alternatives[(b)]	**0** (0.026)	**0** (0.34)	**0** (4.2E-4)	**1** (1.2)	**0** (0.11)	**0** (0.023)
Lower Bound – All Alternatives	**0** (0.029)	**0** (0.37)	**0** (7.7E-4)	**1** (1.4)	**0** (0.14)	**0** (0.037)
Upper Bound – Action Alternatives	**0** (0.074)	**1** (0.59)	**0** (4.7E-3)	**5** (5.1)	**0** (0.48)	**0** (0.16)
Hanford Only – No Action Alternative[(b)]	**0** (0.013)	**0** (0.11)	**0** (2.2E-4)	**1** (0.60)	**0** (0.057)	**0** (0.012)
Washington State						
Hanford Only – Action Alternatives[(b)]	**0** (8.0E-3)	**0** (0.11)	**0** (1.3E-4)	**0** (0.38)	**0** (8.2E-3)	**0** (0.036)
Lower Bound – All Alternatives	**0** (8.9E-3)	**0** (0.11)	**0** (2.1E-4)	**0** (0.46)	**0** (9.7E-3)	**0** (0.042)
Upper Bound – Action Alternatives	**0** (0.022)	**0** (0.17)	**0** (1.2E-3)	**2** (1.6)	**0** (0.034)	**0** (0.15)
Hanford Only – No Action Alternative[(b)]	**0** (4.3E-3)	**0** (0.036)	**0** (7.0E-5)	**0** (0.20)	**0** (4.3E-3)	**0** (0.018)

(a) Radiological impacts (incident-free and accident) are expressed in units of LCFs. Non-radiological accident impacts are expressed as the expected number of accidents and the resulting physical trauma fatalities. Non-radiological emissions impacts are expressed as LCFs.

(b) TRU wastes to WIPP.

One to four accidents were calculated to occur during transport of construction and capping materials for Alternative Groups A through E, and four accidents were estimated for the No Action Alternative. No fatalities were forecast in any case.

3.4.9 Noise

Because all alternatives would involve essentially the same activities, noise levels produced by those activities at any given point in time would be essentially the same. Noise was not considered to be an important impact element because of distance to public receptors. Wildlife that might be disturbed by noise near the Area C borrow pit likely would move to more distant locations. Details of the analysis of noise are presented in Section 5.9 and Volume II, Appendix J. Based on the level of activity associated with waste management operations and the location of the activities within the Hanford Site, noise levels are predicted to be well within allowable limits at locations occupied by members of the public.

3.4.10 Resource Commitments

Resources committed to implementing the various alternative groups (including the No Action Alternative) would include land; the vadose zone beneath the disposal facilities; groundwater beneath the disposal sites and on to where it empties into the Columbia River; and various amounts of fossil fuel, electricity, steel, concrete, gravel, sand, gravel, silt/loam, basalt, water, and other materials. Land use and geologic resources were described previously (Tables 3.9 and 3.13). Comparison of fossil fuel commitments among the alternatives is provided in Table 3.16. Alternative Groups A and B and the No Action Alternative have generally higher demand for fossil fuels than the other alternative groups because of additional construction and operation required. Details of the analysis of resource commitments are presented in Section 5.10.

3.4.11 Human Health and Safety

Comparison of human health and safety among the alternatives is expressed in terms of worker dose, dose to the public from atmospheric releases, accidents during the operational period, and long-term impacts via the groundwater pathway in the post-closure period. Details of the analyses are provided in Section 5.11 and Volume II, Appendix F. Intruder scenarios and consequences are essentially the same for all alternative groups. The exception would be for the basement excavation scenario in the No Action Alternative where only Trenches 31 and 34 containing MLLW are capped. The depth of capping material would be expected to preclude the occurrence of that scenario for those wastes.

Table 3.16. Comparison of Fossil Fuel Commitments Among the Alternatives

Alternative	Diesel, m3[(b)]			Gasoline, m^3			Propane, tonnes[(a)]		
	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume
Alternative Group A	132,900	132,900	133,700	260	260	270	12,700	12,700	19,300
Alternative Group B	136,600	136,700	140,600	340	340	430	23,500	23,500	38,300
Alternative Group C	65,900	65,900	66,700	260	260	270	12,700	12,700	19,300
Alternative Group D	65,900	65,900	66,700	260	260	270	18,800	20,300	27,800
Alternative Group E	65,900	65,900	66,700	260	260	270	18,800	20,300	27,800
No Action Alternative	188,600	188,700	Not applicable	48	50	Not applicable	3,560	3,560	Not applicable

(a) 1 tonne = about 1.1 ton.
(b) Includes 120,100 m^3 for ILAW in Alternative Groups A and B, 53,100 m^3 for ILAW in Alternative Groups C, D, and E, and 183,400 m^3 for ILAW in the No Action Alternative.

3.4.11.1 Operational Period – Normal Operations

Radiological impacts to workers from air emissions and routine occupational radiation exposure through 2046 are compared among the alternatives in Table 3.17. No latent cancer fatalities (LCFs) would be expected from doses associated with any of the action alternatives; however, one LCF might be inferred from the No Action Alternative.

Table 3.17. Comparison of Worker Health Impacts

Alternative	Non-Involved Worker, mrem[(a)]			Occupational Exposure, person-rem[(b)]		
	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume
Alternative Group A	0.48	0.58	0.89	765	766	774
Alternative Group B	0.48	0.58	0.89	772	773	786
Alternative Group C	0.48	0.58	0.89	765	765	773
Alternative Groups D and E	0.48	0.58	0.89	767	767	778
No Action Alternative	0.48	0.58	Not applicable	873	873	Not applicable

(a) Lifetime dose to the hypothetical maximally exposed individual (MEI) based on the industrial worker scenario.
(b) Work force external exposure from proximity to wastes.

Radiological impacts on the public from the release of radioactive material to the atmosphere during routine operations through 2046 are compared among the alternatives in Table 3.18. (For more details, see Section 5.11.) No LCFs would be expected from the doses presented.

Table 3.18. Comparison of Public Health Impacts from Emissions of Radioactive Material to the Atmosphere During Routine Operations

Alternative	Population Dose, person-rem[(a)]			MEI Lifetime Dose, mrem[(b)]		
	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	Hanford Only Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume
Alternative Groups A, C, D, and E	0.15	0.17	0.24	0.0016	0.0018	0.0025
Alternative Group B	0.19	0.21	0.29	0.0021	0.0023	0.0032
No Action Alternative	0.10	0.12	Not applicable	0.0011	0.0013	Not applicable

(a) Collective population dose within 80 km (50 mi) based on the offsite resident gardener scenario as applied to average individuals in the population (see Appendix F).
(b) Lifetime dose to the hypothetical MEI based on the offsite resident gardener scenario.

3.4.11.2 Operational Period – Accidents

The consequences of industrial accidents on workers through 2046 are compared among the alternatives in Table 3.19.

Table 3.19. Comparison of Consequences of Industrial Accidents on Workers Among the Alternatives

Alternative	Total Recordable Cases		Lost Work Day Cases		Lost Work Days	
	Hanford Only and Lower Bound Waste Volumes	Upper Bound Waste Volume	Hanford Only and Lower Bound Waste Volumes	Upper Bound Waste Volume	Hanford Only and Lower Bound Waste Volumes	Upper Bound Waste Volume
Alternative Groups A, C, D, and E	620	640	260	260	8900	9200
Alternative Group B	640	660	260	270	9000	9300
No Action Alternative	770	NA	320	Not applicable	10,900	Not applicable

Impacts on public health and safety from processing chemicals through 2046 are compared among the alternatives in Table 3.20.

Table 3.20. Comparison of Health Impacts on the Public from Routine Atmospheric Releases of Chemicals

Alternative	Hazard Quotient[a]		Cancer Incidence[b]	
	Hanford Only and Lower Bound Waste Volumes	Upper Bound Waste Volume	Hanford Only and Lower Bound Waste Volumes	Upper Bound Waste Volume
Alternative Groups A, C, D, and E	1.1E-5	5.0E-5	1.2E-10	4.2E-10
Alternative Group B	3.8E-4	4.2E-4	7.0E-9	7.3E-9
No Action Alternative	5.3E-6	Not applicable	8.9E-11	Not applicable

(a) Peak annual hazard quotient values to the hypothetical MEI based on the offsite resident gardener scenario.
(b) Lifetime risk of cancer incidence to the hypothetical MEI based on the offsite resident gardener scenario.

For chemicals, there is no difference in impacts between the Hanford Only and the Lower Bound waste volumes because the difference in MLLW processing is small (0.4 percent volume difference).

No particular distinction was made among any of the alternatives for operational accidents involving either radiological or chemical materials. Details are provided in Section 5.11.

3.4.11.3 Post-Closure Period

Analyses in this HSW EIS include two scenarios for intrusion into waste sites soon after the time when active institutional control is assumed to be absent. These scenarios consist of drilling through the waste in constructing a well and excavation of a basement for a house. The importance of these scenarios lies in the presence of short- to intermediate-lived radionuclides that may occur in quantity. In the case of drilling, the existence of a cap over the waste is assumed to constitute no deterrence. Inasmuch as the highest concentrations of radionuclides that are used in this analysis are common to all alternatives, there would be no distinction among the alternatives based on this type of intrusion (the highest concentrations of radionuclides were determined to occur in waste previously disposed of in LLBGs). In the case of excavation for a basement, the depth to the top of the disposed waste is deep enough in all alternatives for which the waste sites are capped that the scenario is not considered credible. In the No Action Alternative where it is assumed that only the MLLW sites are capped, the depth to the top of the waste would be much less and waste could be encountered in the excavation. In any event, these intruder scenarios for the alternative groups (except the No Action Alternative) do not provide a basis for discriminating among the alternatives. Details of these intruder analyses are presented in Section 5.11.2.2 and Volume II, Appendix F.

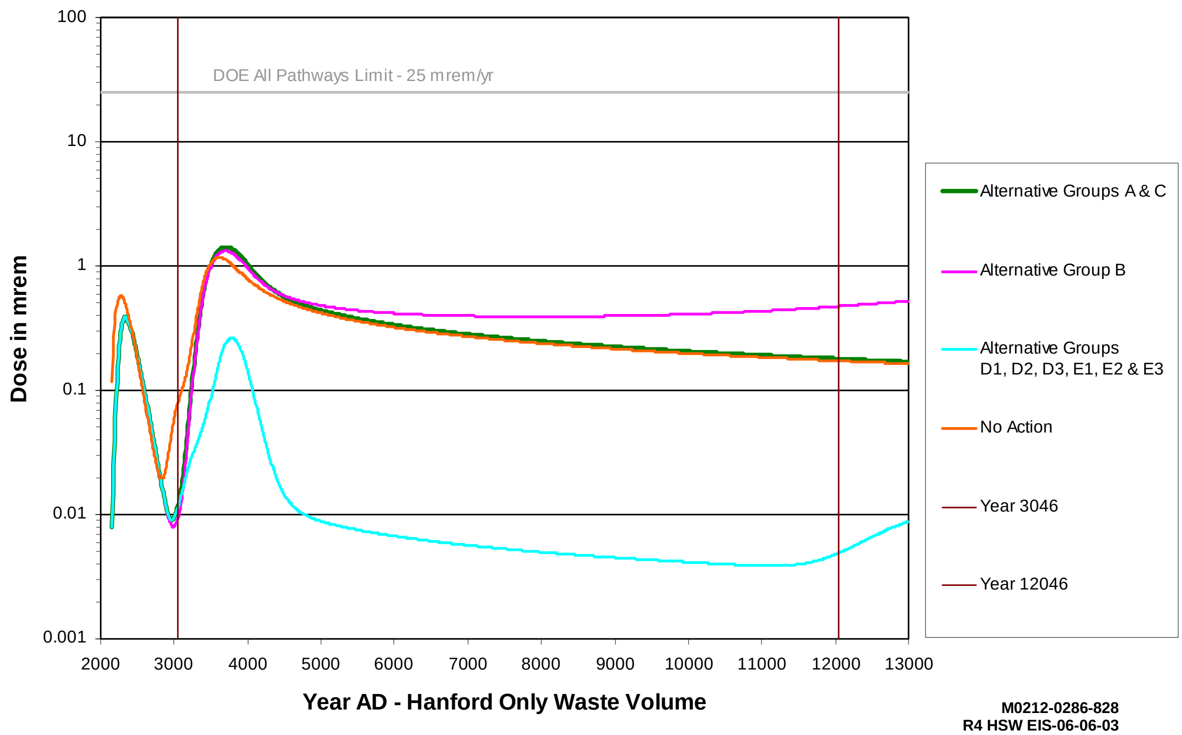
Insights regarding the relative potential for impacts on the public over the long term may be obtained by examining the annual dose a hypothetical gardener might receive, if the individual were to intrude on the Hanford Site, drill a well (on the order of 80 to 90 m deep [about 250 ft]) into a contaminated aquifer, spread the drilling mud about the garden plot, and use the well water for both domestic and irrigation purposes. Hypothetical wells near the disposal facilities are located 1 km (0.6 mi) from the aggregated waste sites in order to capture the front of the combined plume from the individual trenches. In addition, a well is modeled near the Columbia River where an individual might drill a shallow well rather than use debris-containing water directly from the river. Plots of the annual doses to the hypothetical resident gardener are provided in Figures 3.9 through 3.13. (The vertical line represents 1,000 years after closure of the disposal facilities.) Because the plots for the Hanford Only and Lower Bound waste volumes are essentially the same, plots are provided only for the Hanford Only and Upper Bound waste volumes. As may be seen in the figures, there are differences in the annual doses over time as a function of alternative; however, the maximum values are all small compared with DOE's 25-mrem all-pathways limit and, except for the period beginning about 9,000 years after disposal, the doses are below the DOE benchmark drinking water standard of 4 mrem/yr. Most of the variation in groundwater radionuclide concentrations among the alternatives resulted from proposed locations and configurations for new disposal facilities; differences between the Hanford Only and Upper Bound waste volumes were minimal.

To account for the possibility that the hypothetical gardener had a sauna (or in the case of a Native American, a sweat lodge), the annual dose to such an individual at any time during the 10,000-year period of analysis also was estimated. Plots of the annual doses to the resident gardener are compared among the alternatives in Figures 3.14 through 3.18. The much higher doses associated with the sauna/sweat lodge scenario are attributable to inhalation of radionuclides released as a result of elevated water temperatures used in saunas or sweat lodges. For all alternatives the annual dose is at or less than the DOE benchmark 4 mrem/yr drinking water standard for the first 5,000 years. Late in the 10,000-year period there is an increase in the risk of an LCF due primarily to the arrival of uranium in groundwater. For a hypothetical 70-year residency at locations on the Central Plateau, the risk for the sauna/sweat lodge scenario would range from up to about 8 in 10,000 for the action alternatives to 200 in 10,000 for the No Action Alternative. For a location near the river, the corresponding risk would range from up to 3 in 10,000 for the action alternatives to 6 in 10,000 for the No Action Alternative.

For perspective, it may be noted that a hypothetical gardener with the sauna or sweat lodge scenario, and using water drawn from the Columbia River at Priest Rapids upstream of the Hanford Site, could receive an annual dose of about 96 mrem from upstream sources of uranium (based on 5-year average measurements of the concentration of uranium in the Columbia River water at Priest Rapids [Poston et al. 2002]). Over a 70-year period at such an annual dose, the chances of an LCF would be about 4 in 1000 (see Section 5.14.6.3 for more information.)

3.4.12 Cumulative Impacts

Differences in impacts from implementing the various alternative groups would be small and thus potential cumulative impacts associated with implementing the various alternative groups and waste volumes would be similar for all alternatives (see Section 5.14, Cumulative Impacts).



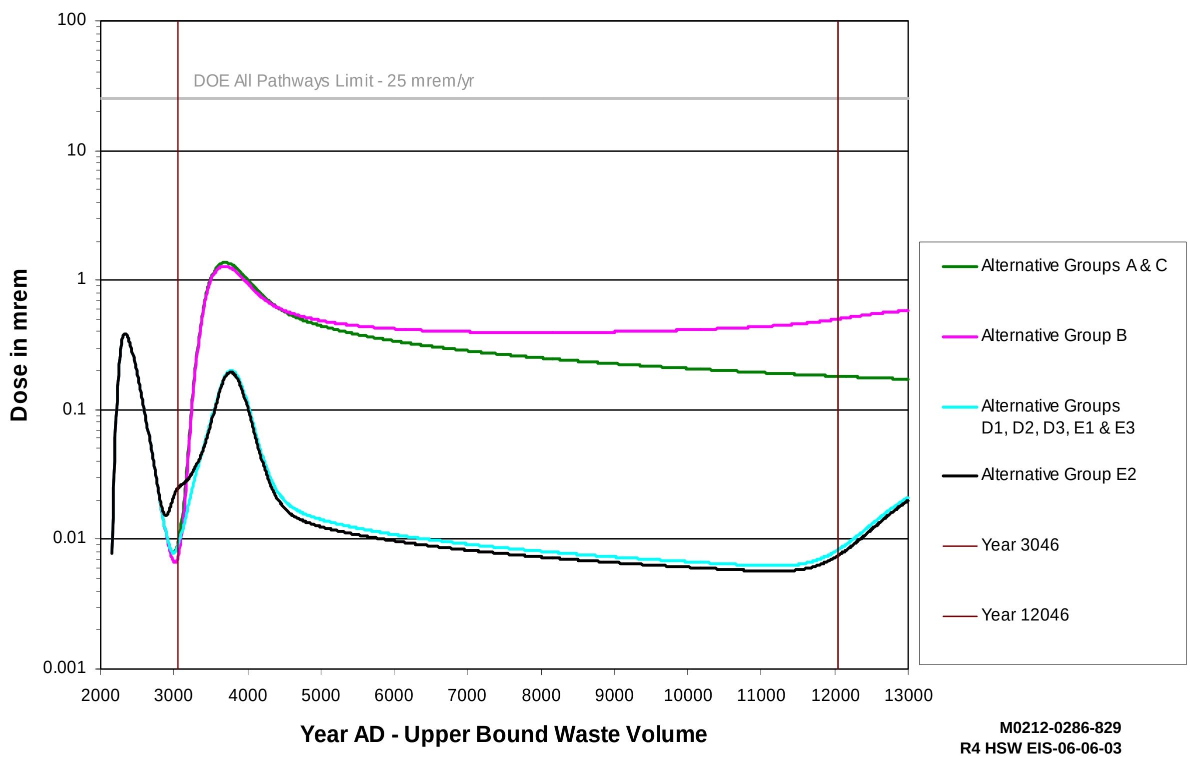
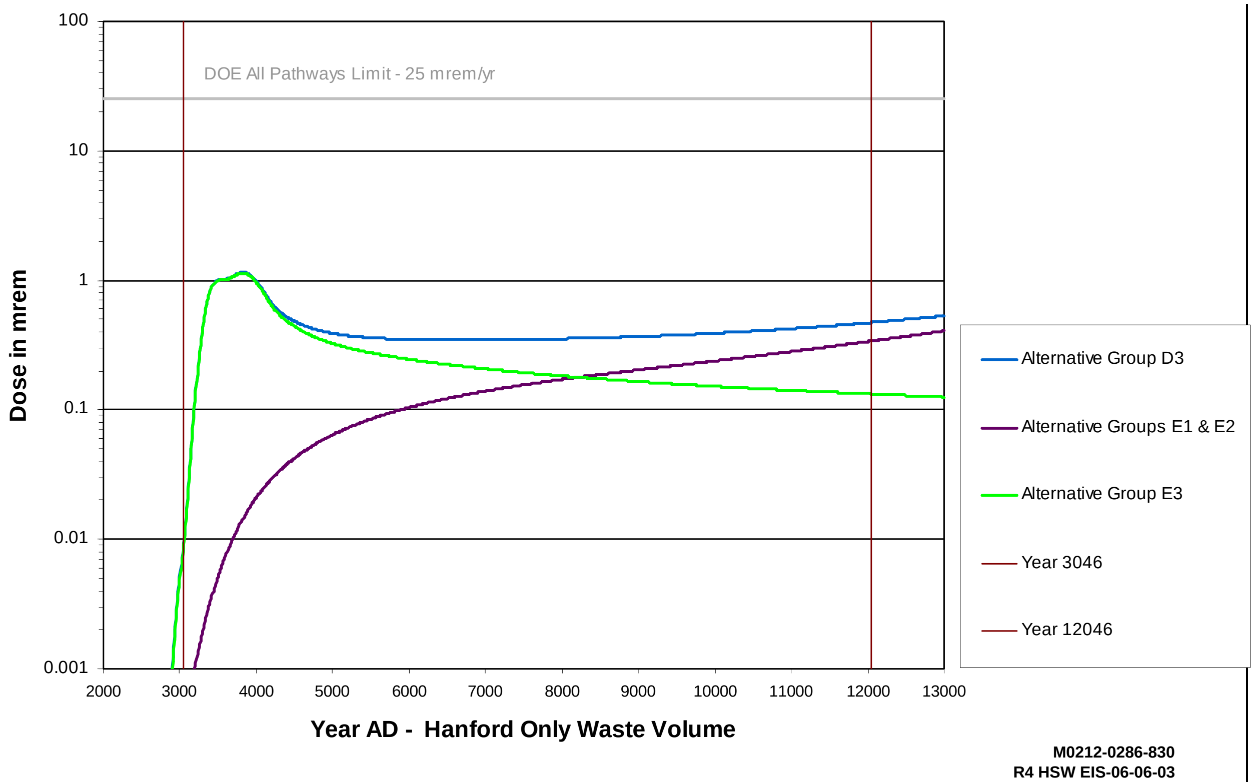


Figure 3.9. Annual Dose to a Hypothetical Resident Gardener at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient from the 200 West Area



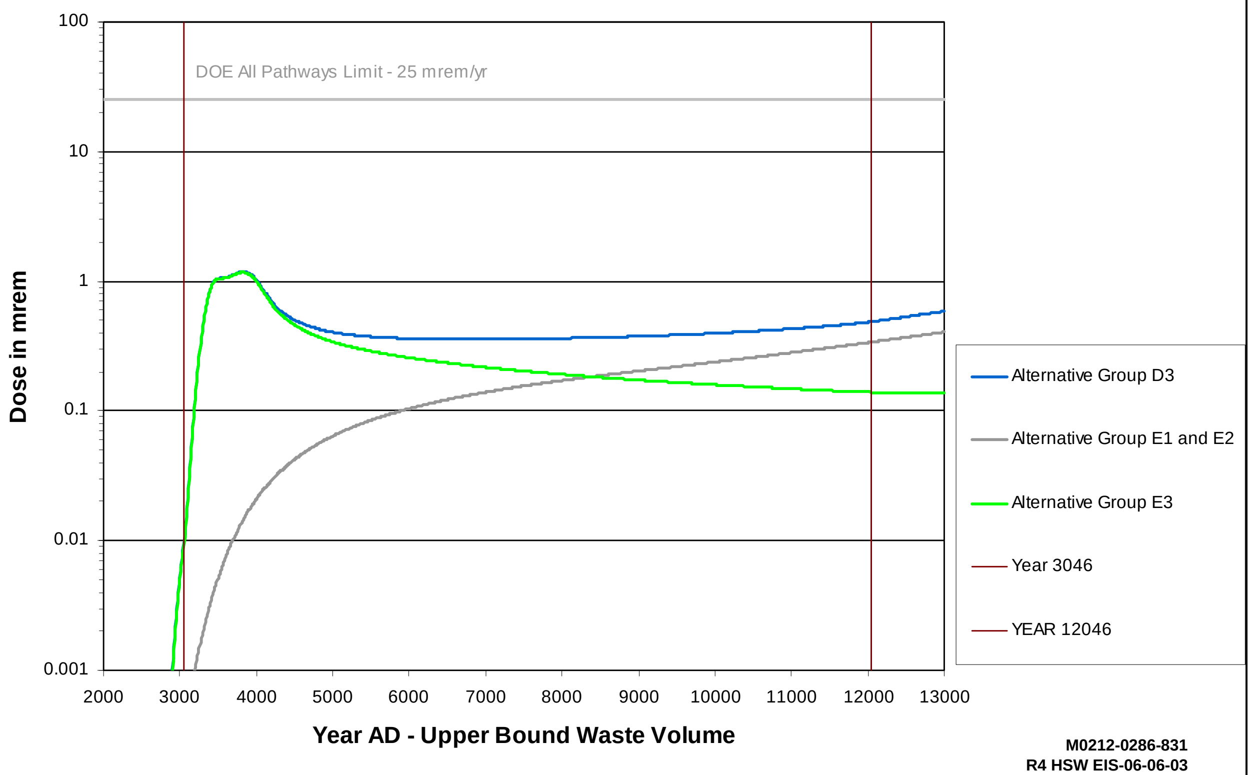
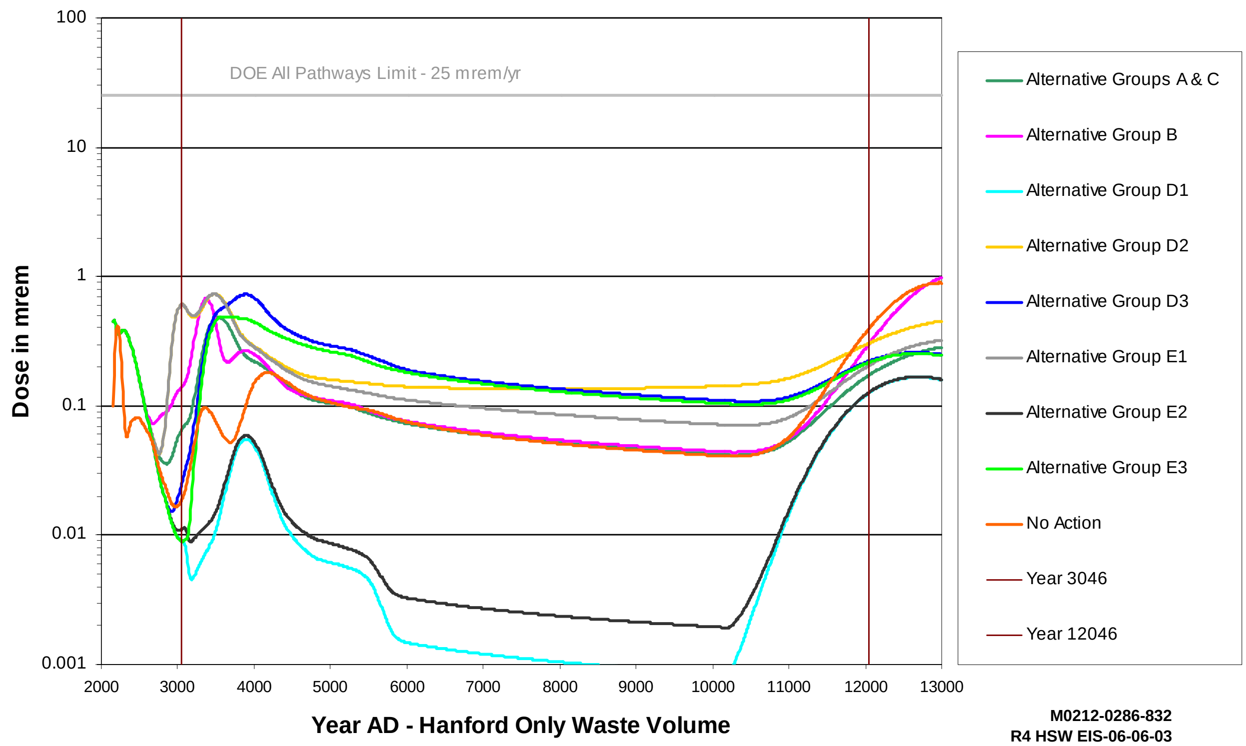


Figure 3.10. Annual Dose to a Hypothetical Resident Gardener at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient from ERDF



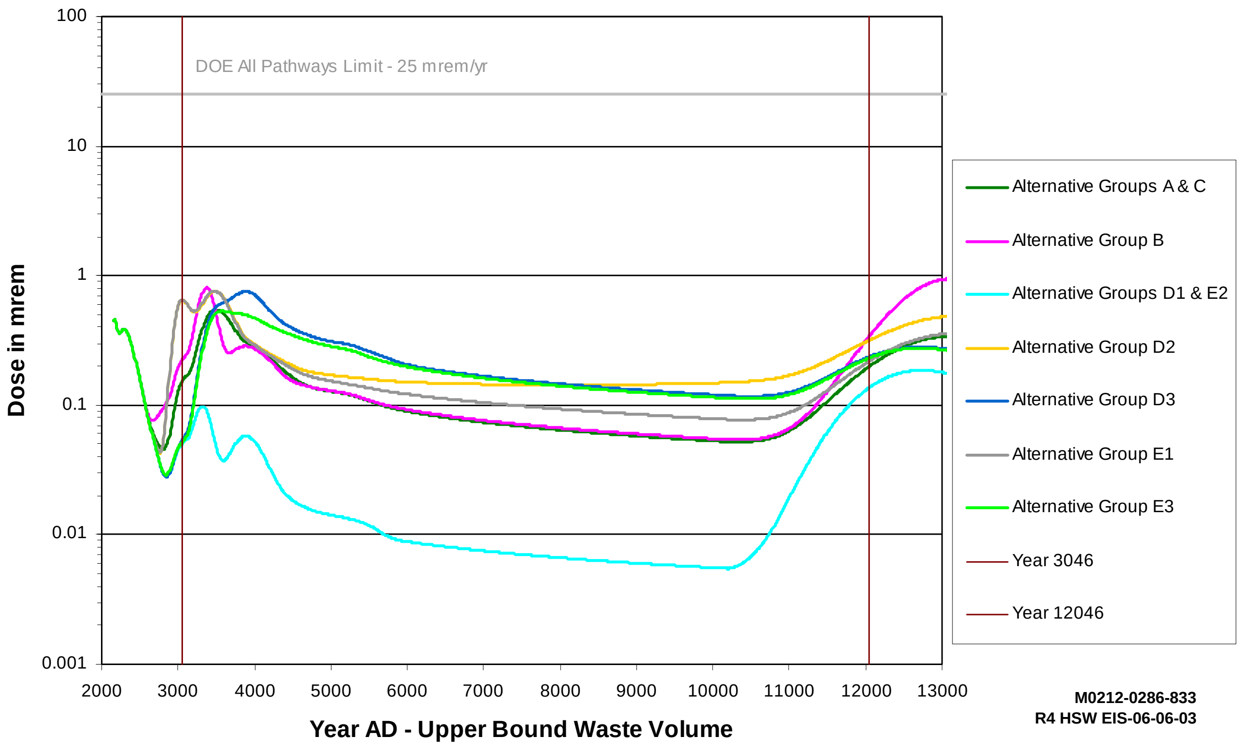
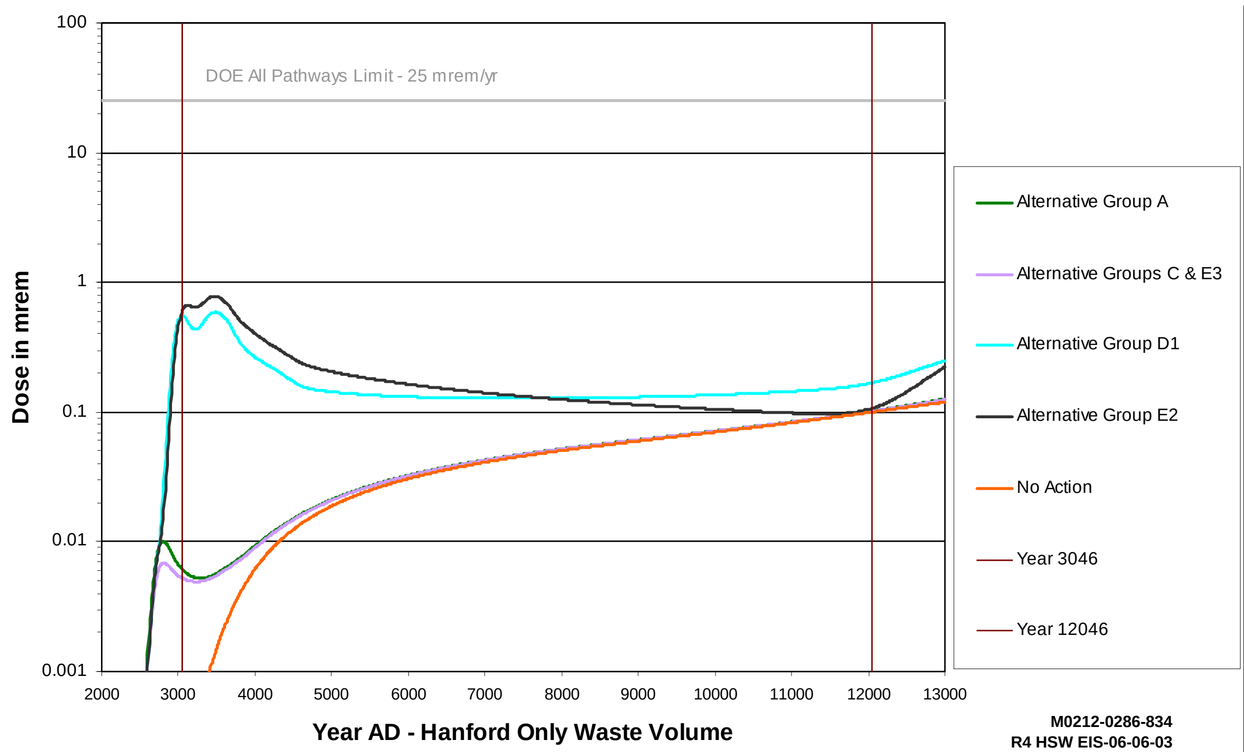


Figure 3.11. Annual Dose to a Hypothetical Resident Gardener at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient Northwest from the 200 East Area



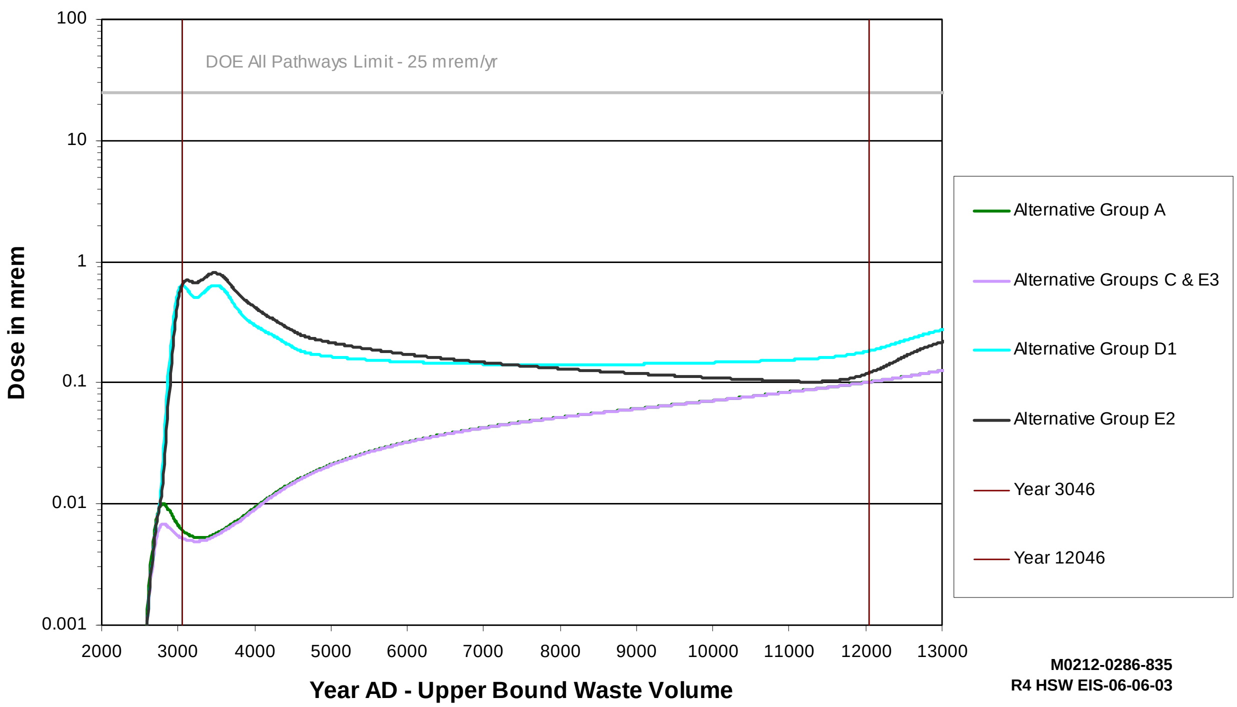


Figure 3.12. Annual Dose to a Hypothetical Resident Gardener at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient Southeast from the 200 East Area

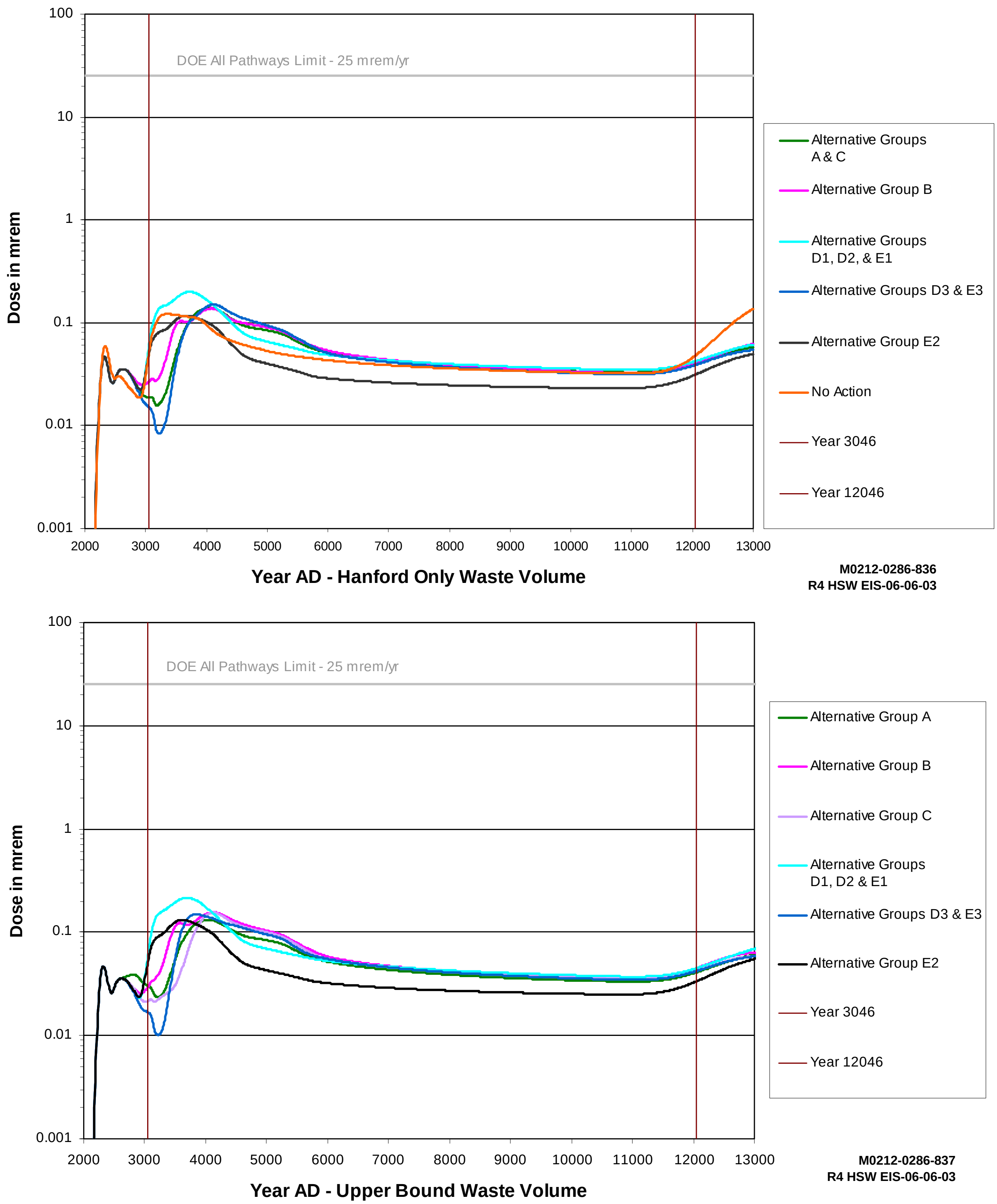
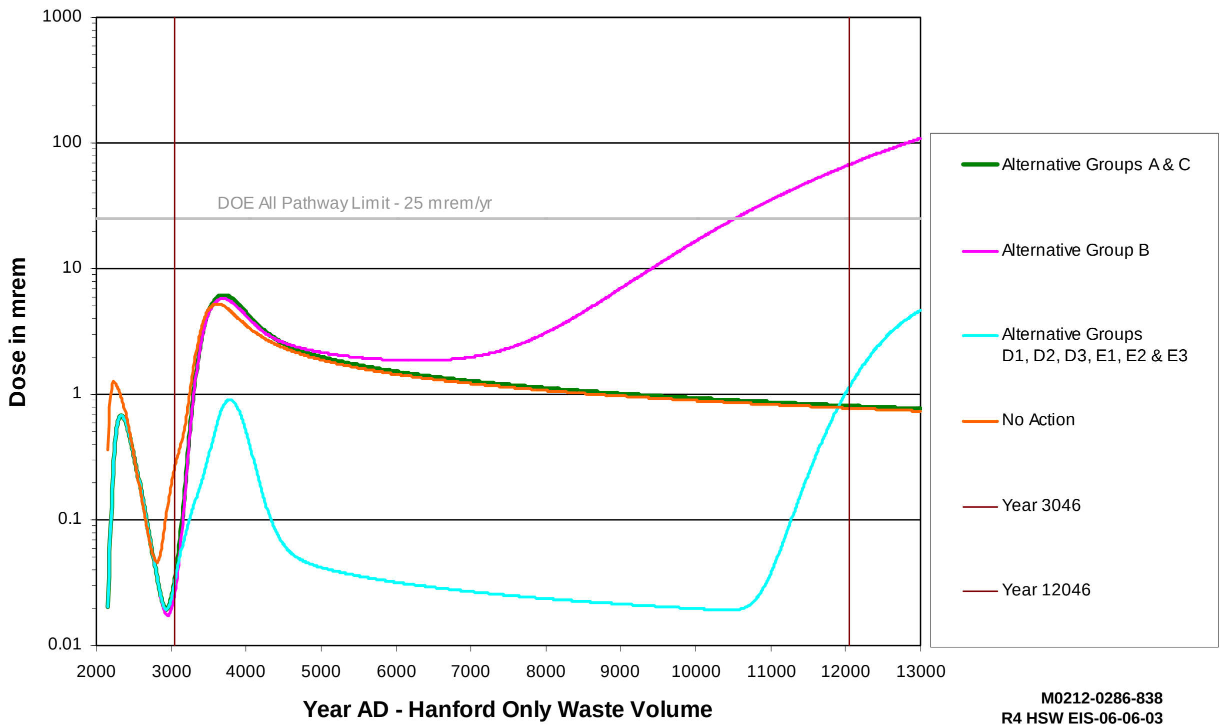


Figure 3.13. Annual Dose to a Hypothetical Resident Gardener at Various Times over 10,000 Years Using Water from a Well Adjacent to the Columbia River



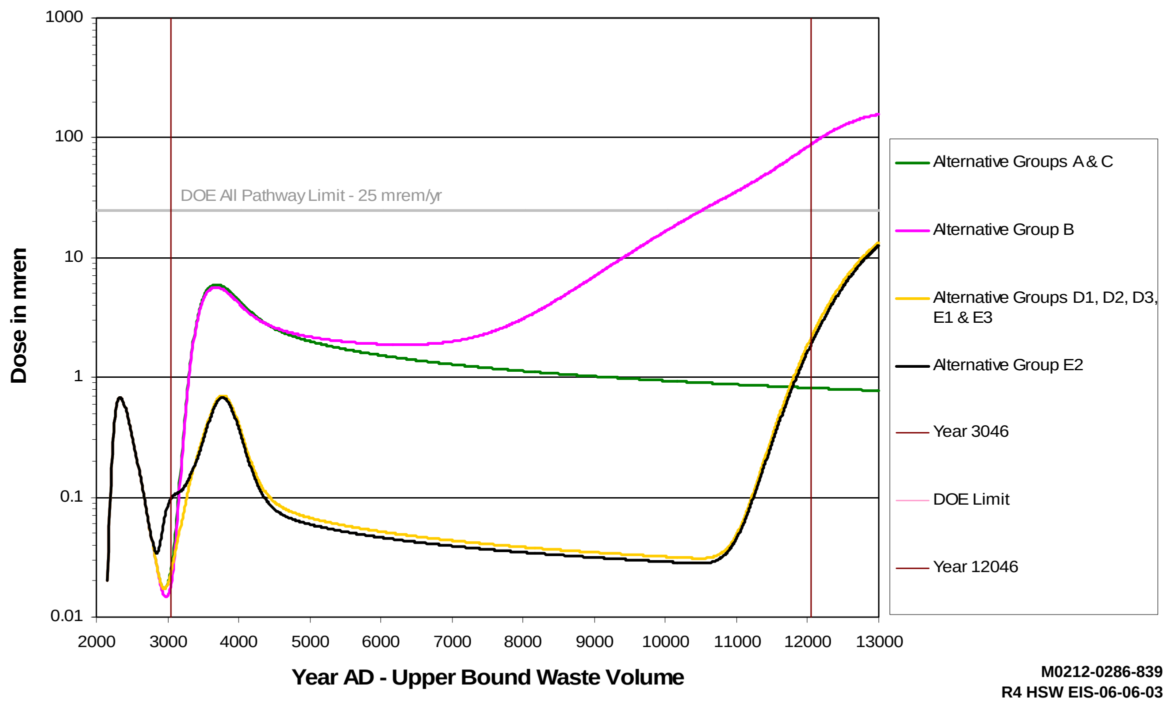
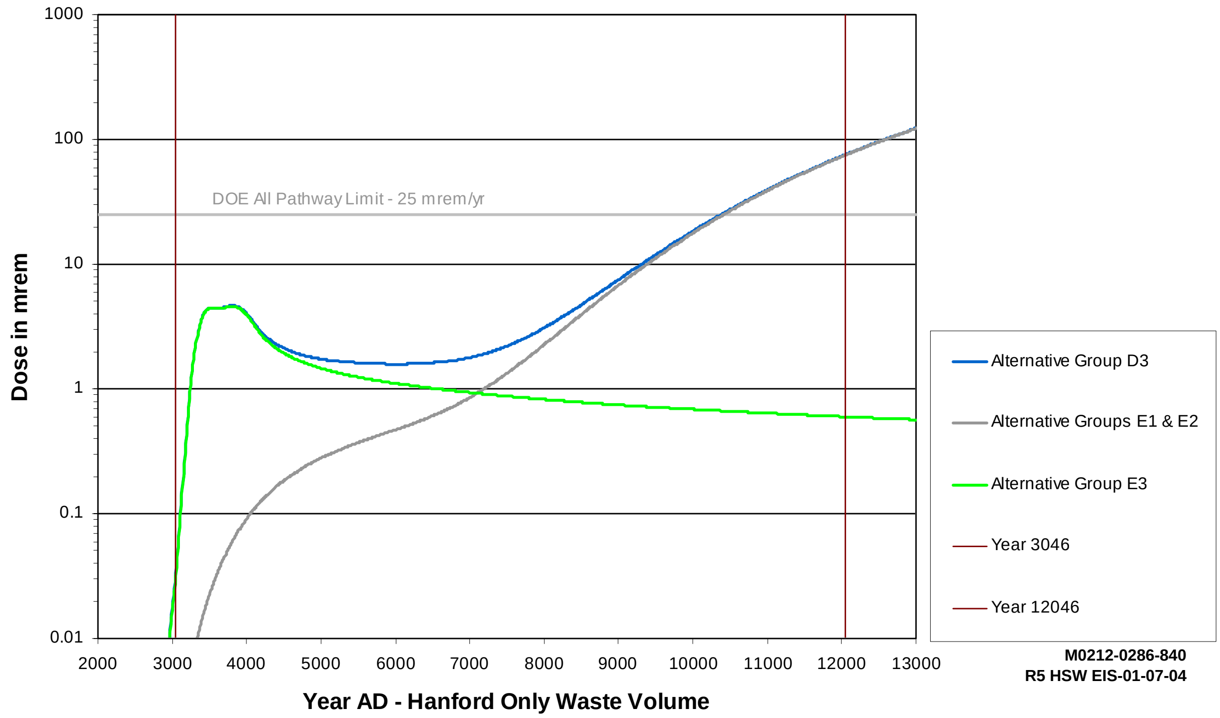


Figure 3.14. Annual Dose to a Hypothetical Resident Gardener with Sauna/Sweat Lodge at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient from the 200 West Area



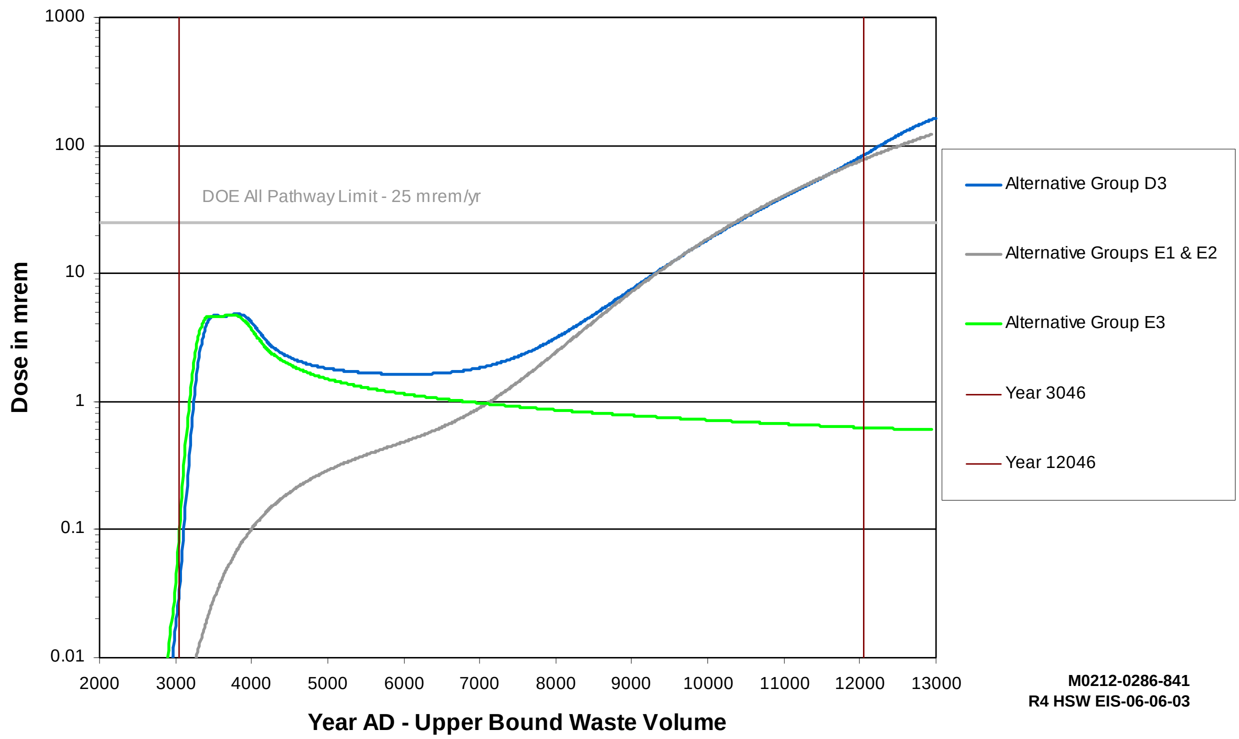
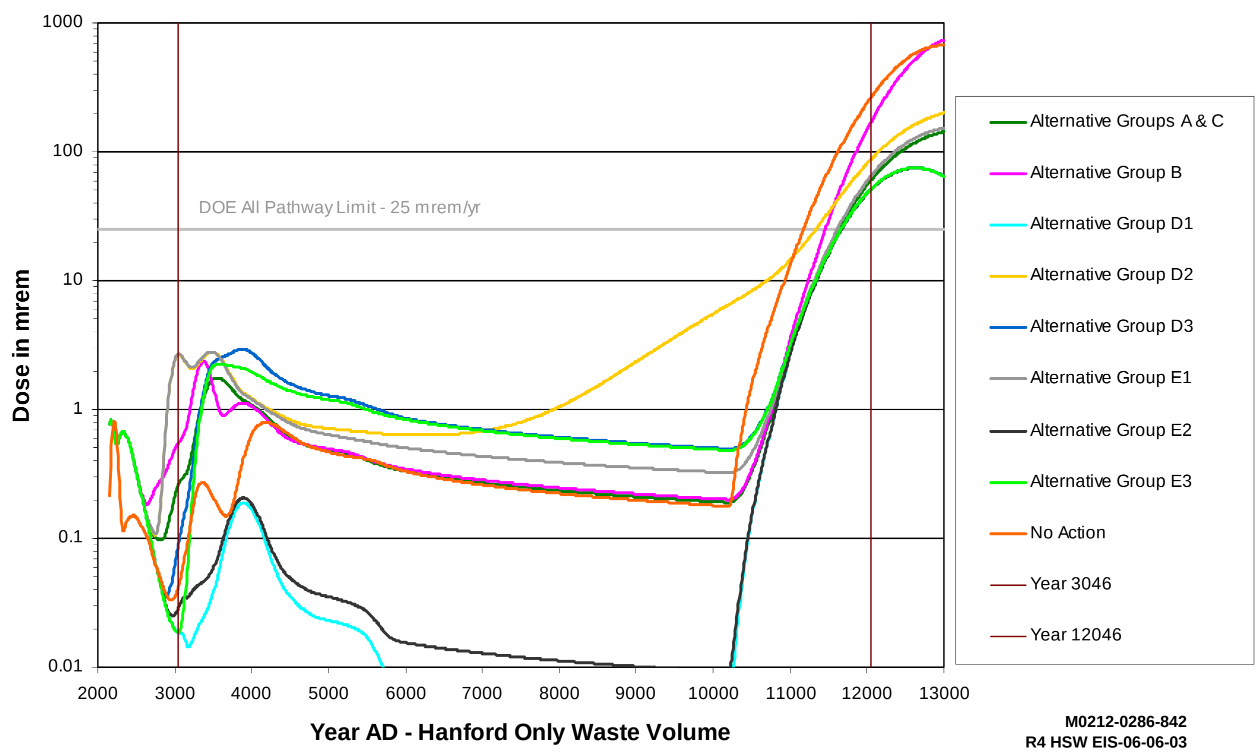


Figure 3.15. Annual Dose to a Hypothetical Resident Gardener with Sauna/Sweat Lodge at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient from ERDF



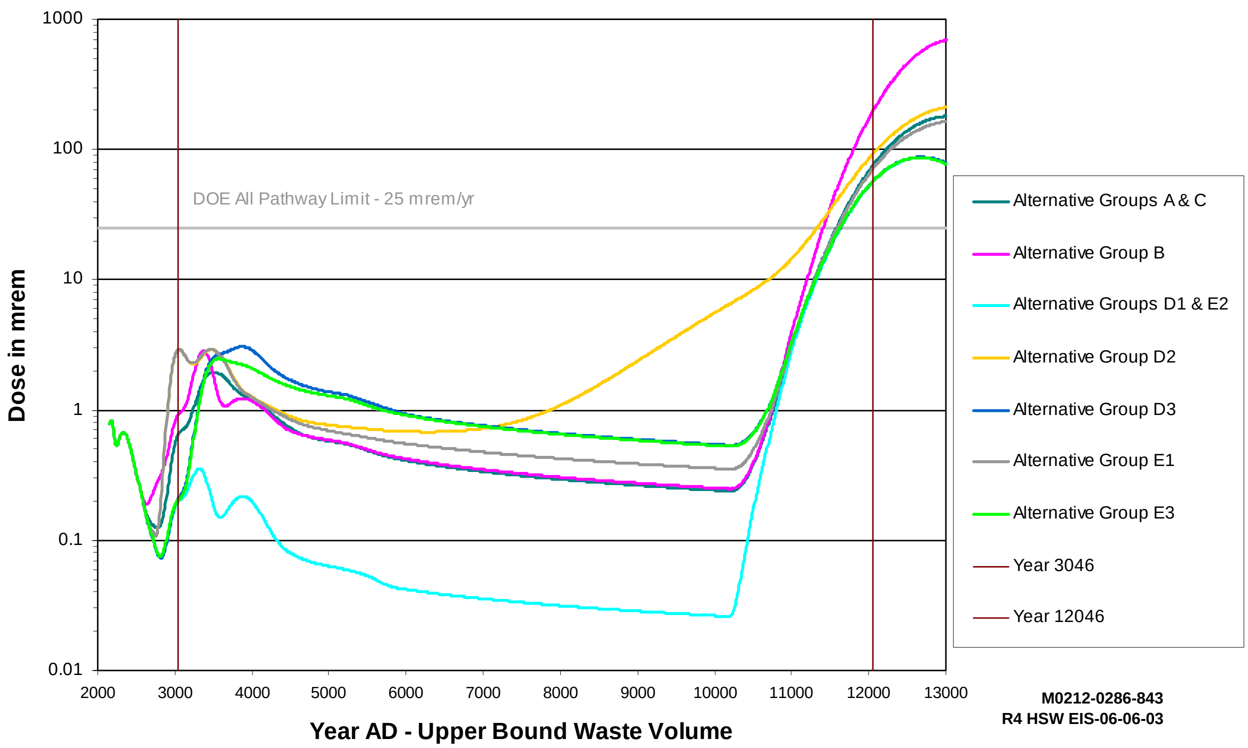


Figure 3.16. Annual Dose to a Hypothetical Resident Gardener with Sauna/Sweat Lodge at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient Northwest from the 200 East Area

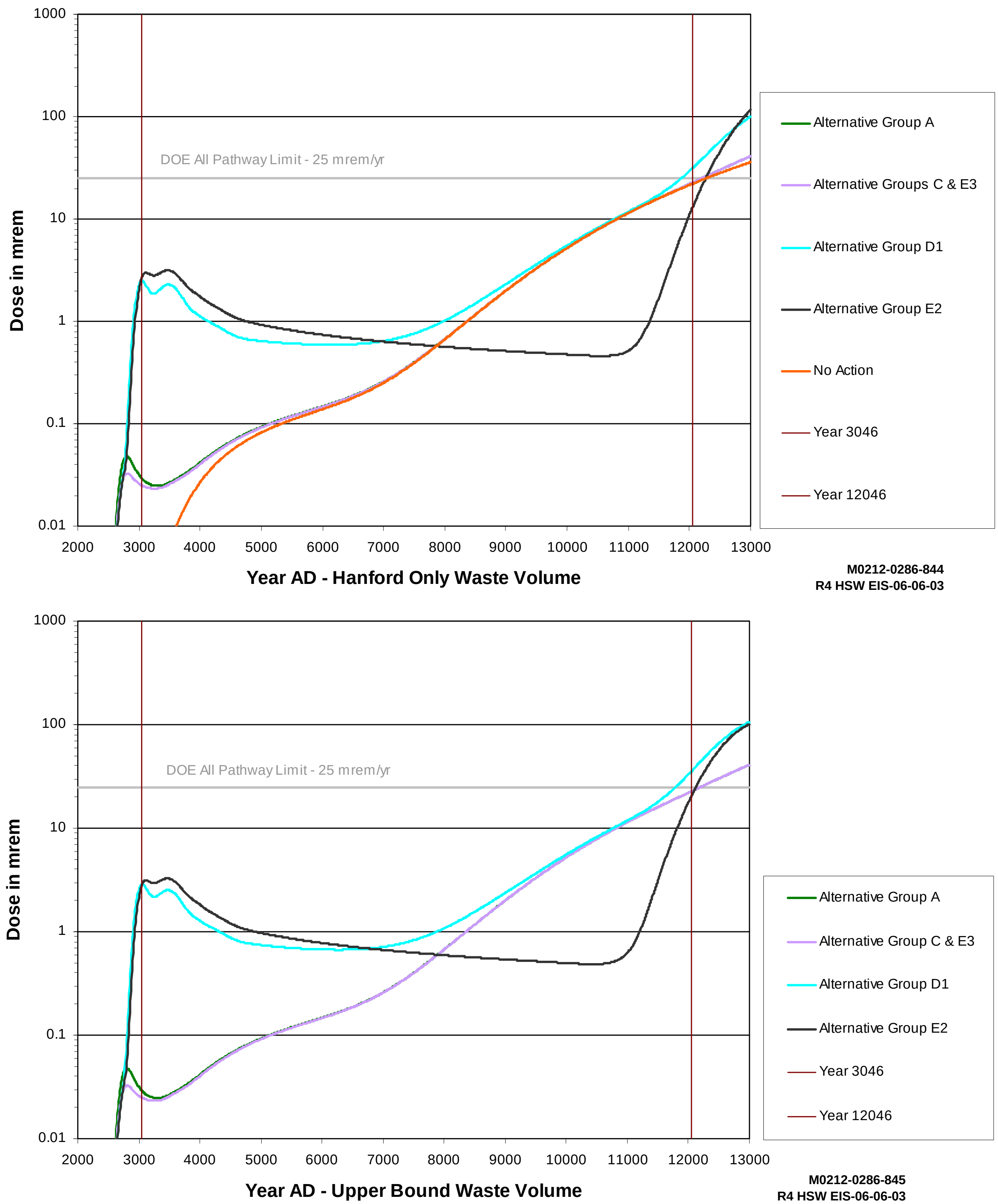


Figure 3.17. Annual Dose to a Hypothetical Resident Gardener with Sauna/Sweat Lodge at Various Times over 10,000 Years Using Water from a Well 1 km Downgradient Southeast from the 200 East Area

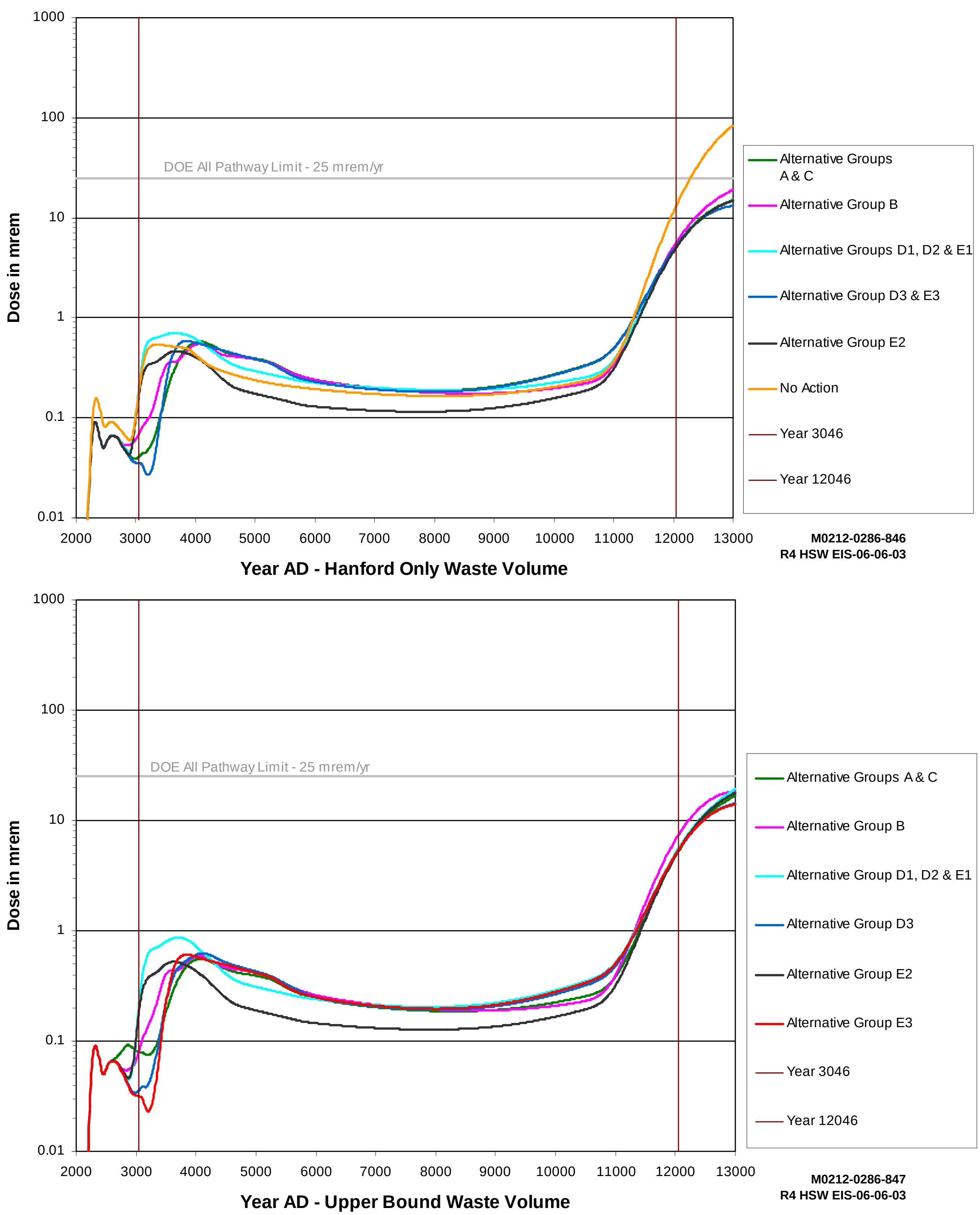


Figure 3.18. Annual Dose to a Hypothetical Resident Gardener with Sauna/Sweat Lodge at Various Times over 10,000 Years Using Water from a Well Adjacent to the Columbia River

3.5 Areas of Uncertainty, Incomplete, or Unavailable Information

This section discusses uncertainties associated with alternatives evaluated in the HSW EIS, and takes into account areas where information is either incomplete or unavailable. Because an EIS is by nature a document prepared during the planning stages for a proposed action, information needed to evaluate environmental impacts of the activities in detail may not always be available. In some cases, there are uncertainties that cannot be resolved by collection or development of additional information, such as the uncertainties associated with projected environmental impacts at very long times in the future, or those associated with inherent variability in human and ecological systems. The approach used to account for these uncertainties would vary with the nature of the impact being evaluated and the methods used for the assessment. The individual analyses of environmental impact areas in Section 5 provide additional detail regarding uncertainties unique to each evaluation where applicable.

The National Council on Radiation Protection and Measurements (NCRP 1996) provides guidelines for performing uncertainty analyses in dose and risk assessments, including guidance for determining when uncertainty analysis is warranted, methods for performing uncertainty analyses, and elicitation of expert judgment for use in uncertainty analysis. A detailed quantitative uncertainty analysis may not be necessary or possible when

1. Conservatively biased screening calculations indicate that the risk from possible exposure is clearly below regulatory or risk levels of concern.
2. The cost of an action required to reduce exposure is low.
3. Data for characterizing the nature and extent of contamination at a site are inadequate to permit even a bounding estimate (an upper and lower estimate of the expected value).

Conditions that may justify preparation of a quantitative uncertainty analysis include

1. An erroneous result in the dose or risk assessment may lead to large or unacceptable consequences.
2. A realistic rather than a conservative estimate is needed.
3. A need to set priorities for the assessment components for which additional information will likely lead to improved confidence in the estimate of dose and risk.

The HSW EIS analyses rely on various modeling approaches to predict consequences of actions that DOE may undertake in the future. In some cases, the model may be a simple scaling of available data for similar activities to the specific scope of activities expected for each of the EIS alternatives. For example, average historical radiation doses to waste management workers could be used to predict collective doses for the number of workers required to carry out the proposed actions. In other cases, the models may be extremely complex and require inputs of data and assumptions that are subject to much more uncertainty. In this EIS, estimation of long-term performance for waste disposal facilities involves such a model, which requires extensive inputs of information related to quantities of potentially hazardous constituents in the facility, release of those constituents from the waste, transport of the materials through the vadose zone and groundwater, and ultimate use of groundwater or the Columbia River for various activities such as agriculture or recreation. In such models, historical data for the necessary input information does not always exist over the time periods of interest, or it may be highly variable because of inherent unpredictability in the behavior of geological, biological, or ecological systems.

Two approaches are typically used to address uncertainty in conducting analyses of prospective impacts and risk. The simplest involves using conservative input data and assumptions for the parameters of interest, such that actual consequences are unlikely to exceed the estimated consequences. This approach is often used in demonstrating compliance with regulatory standards, for example, to ensure comparability among assessments for different sites and facilities, and for consistency with methods used to develop the standards themselves. It is also the approach typically used in this EIS to assess consequences where detailed information about facility design and activities are evolving or awaiting future decisions. In most cases, it provides sufficient information to ensure that proposed actions would meet applicable regulatory standards and to compare the relative impacts of various alternatives.

Conservative Assumptions in the HSW EIS

Within this EIS, the term "conservative" refers to assumptions used in the various environmental consequence analyses that tend to bound, maximize, or overestimate the potential impacts. Such assumptions are typically used when specific information regarding an activity is not available, or is at a conceptual stage of development. These assumptions are used to ensure that the analyses do not underestimate the effects of the proposed actions on human health and the environment.

A second possible approach is to conduct an uncertainty analysis that produces a statistical distribution of potential consequences. The distribution of results provides a measure of central tendency for the consequence of interest (mean, median, or mode), as well as a measure of the likelihood of consequences at the extreme ends of the distribution (95% confidence limits, for example). This approach involves developing distributions of values for each of the key input parameters in a model and performing a series of calculations, using randomly selected values from the input distributions, to produce the statistical distribution of potential consequences. However, this type of analysis requires extensive effort and may be limited by availability of information with which to develop the required input parameter distributions. It is typically not necessary for the types of analyses included in this EIS, although it has been applied to the cumulative long-term impacts on groundwater (see Appendix L). The following sections provide a general discussion of uncertainties associated with the HSW EIS analyses and the manner in which they are addressed. Additional information is provided in the sections that present the analysis results and their associated appendixes.

3.5.1 Waste Volumes

The volume of wastes that could ultimately be managed at Hanford represents one of the larger uncertainties associated with the analyses in this EIS. Many of the impact assessments depend on the waste volume that ultimately requires treatment or disposal onsite. Forecasts of future waste volumes from Hanford generators have been compiled for a number of years, and have been shown to be reasonably accurate, if somewhat conservative overall (see Appendix B). Potential waste receipts from offsite generators are associated with uncertainties due to cost, schedule, and other factors. The performance assessment process for disposal facilities may also limit incoming waste quantities in order to ensure compliance with applicable requirements. The HSW EIS accounts for this uncertainty by evaluating a range of waste volumes as described in Section 3.3. Those waste volumes represent estimates of the minimum and maximum waste quantities reasonably expected to be received at Hanford during active waste management operations. The basis for the waste volumes is described in Appendixes B and C.

3.5.2 Waste Inventories of Radioactive Materials

The quantities of radioactive components in waste also contribute to environmental impacts, particularly those associated with air emissions and long-term performance of disposal facilities. The basis for waste inventories varies with the type of waste and its source, and may include information such as process knowledge or direct assay. In general, inventories for wastes received in recent years are expected to be associated with less uncertainty than those disposed of in the early 1970s. Wastes received in later years are more fully characterized because of improved analytical capabilities and added requirements for record keeping. The HSW EIS analyses account for those uncertainties by making conservative assumptions (that is, assumptions that would tend to maximize the impacts) regarding waste inventories based on process knowledge, assays of previously received waste, or other available information from waste generators. For example, the inventory of iodine-129 in past and potential future waste receipts has been estimated using the total production at Hanford, sampling of releases to the atmosphere from fuel processing facilities, and analytical information on tank waste and other waste streams. That inventory is expected to overestimate iodine-129 actually disposed of at Hanford for reasons described in Appendix L.

Wastes and residual soil contamination remaining at Hanford over the long term that are not specifically evaluated as part of the HSW EIS alternatives may also contribute to contamination of groundwater and the Columbia River. Impacts from some of those wastes were evaluated previously as part of NEPA or CERCLA reviews. For example, the HDW EIS (DOE 1987) and Bryce et al. (2002), suggest that the risks associated with radionuclides in older solid waste sites would be small, consistent with the cumulative impacts analysis in this EIS (see Section 5.14 and Appendix L).

DOE plans to characterize solid waste disposal facilities under RCRA past practice or CERCLA processes to determine whether remedial action would be required before the facilities are closed. Those evaluations for 200 Area facilities are scheduled to be completed in 2008. Therefore, the long-term risks from these wastes would either be determined to be acceptable, or the waste site would be remediated.

3.5.3 Waste Inventories of Non-Radioactive Hazardous Materials

Hazardous chemicals in MLLW have been characterized and documented since the implementation of RCRA at DOE facilities beginning in 1987. MLLW currently in storage, and MLLW that may be received in the future, would be treated to applicable state and federal standards for land disposal. Therefore, disposal of that waste is not expected to present a hazard over the long term because the hazardous components would either be destroyed or stabilized by the treatment. Inventories of hazardous materials in stored and forecast waste are either very small, or consist of materials with low mobility (see Appendixes F and G).

Inventories of hazardous chemicals in wastes were not generally maintained by industries in the United States prior to the implementation of RCRA. Consistent with these general practices, inventories of hazardous chemicals in radioactive waste were not required to be determined or documented before the application of RCRA to radioactive mixed waste at DOE facilities. Therefore, uncertainty regarding the content of hazardous materials in wastes disposed of before that time is generally higher than for radionuclides. Preliminary estimates of chemical inventories in pre-1988 waste have been developed for analysis in the HSW EIS, and a summary of their potential impacts on groundwater is presented in Section 5.3 and Appendix G. A list of the types of hazardous constituents in solid waste disposed of between 1968 and 1988 indicates the presence of some RCRA- or state-designated hazardous inorganic chemicals, acids, oils, solvents, and metals such as lead (DOE-RL 1989; FH 2004). Lead, which comprises the bulk of these materials, was in a solid non-dispersible form that is not highly mobile in groundwater. In cases where limited quantities of liquids were present in wastes received for storage or disposal, they were packaged in multiple containers with sufficient absorbent to contain the liquids (DOE 1985). Practices used to stabilize and contain radionuclides in the waste would also aid in limiting migration of non-radioactive hazardous constituents. Sampling of soil and groundwater upgradient and downgradient from active solid waste disposal facilities has not provided evidence that these facilities contributed to existing groundwater contamination (Hartman et al. 2002). As with the older radioactive waste disposal sites, disposal facilities containing pre-1988 waste would be evaluated using the RCRA past practice or CERCLA processes to determine whether remedial action is required before the facilities are closed. Therefore, the long-term risks from these wastes would either be determined to be acceptable, or the waste site would be remediated.

Most hazardous materials historically used in large quantities at Hanford were organic liquids or solutions containing inorganic compounds and metals such as chromium. Bulk liquid wastes were stored in underground tanks, or disposed of directly to the ground via ponds, trenches, cribs and ditches. The practice of discharging untreated liquid waste to the ground was reduced in the 1980s and discontinued in 1995. Some contaminants have been detected in groundwater as a result of those past liquid waste disposal practices. A previous evaluation of waste disposal sites confirmed that groundwater contamination by hazardous chemicals was primarily a result of past liquid discharges rather than solid waste disposals (DOE 1996).

DOE has an ongoing program to characterize and remediate soil and groundwater contaminated by past liquid discharges (Hartman et al. 2002). For example, some LLBGs in the 200 West Area were sampled recently as part of an ongoing CERCLA investigation to characterize and remediate past carbon tetrachloride discharges in the vicinity of the Plutonium Finishing Plant. Sampling detected the presence of carbon tetrachloride vapor in soil at the bottom of some disposal trenches about 4.6–6.1 m (15–20 ft) below ground. The source of the vapor could not be determined from the initial sampling, but was estimated to be either waste in the disposal trench, or lateral migration of vapor from former liquid discharge sites in the vicinity. The sampling risers were capped except during sample collection, and measured vapor concentrations in air at the ground surface were well within workplace exposure standards. Because of those results, and because the vapor is approximately five times the density of air, there was no evidence that potentially hazardous releases to the atmosphere had occurred. However, additional soil sampling has been planned to investigate the source of the vapor and to determine whether there may have been liquid carbon tetrachloride releases to soil beneath the trenches. Depending on those future findings, remedial actions would be carried out during retrieval of stored transuranic waste from the trenches or at closure of the LLBGs. In all cases, the potential for hazardous material releases to the atmosphere and exposures to workers would be evaluated in advance. Workers would use protective clothing and equipment as required to minimize exposure during sampling or retrieval operations. Other measures, such as extraction of vapor from the soil or use of appropriate containment, would be implemented to ensure that exposures to workers in nearby facilities and offsite members of the public would be within applicable standards.

Hanford's waste tanks also contain a complex mixture of radionuclides and chemicals, which adds a degree of uncertainty to the analyses associated with ILAW disposal. Historical data, such as chemical purchase invoices, records of waste transfers, and process knowledge, have been used to estimate total inventories of materials in the tank waste collectively. There is an ongoing waste characterization program to better determine the contents of each individual tank through sampling and analysis to support safety evaluations and remedial action decisions. Collection of that information continues, but is not yet complete. The lack of detailed characterization information on a tank-by-tank basis adds a level of uncertainty to certain aspects of the tank waste treatment project. However, that information is less critical to determining the long-term impacts of disposal, which are based on the total ILAW inventory. Treatment processes that would affect the composition and form of the final product are still under investigation as well. Some of the processes under consideration have not been applied to this type of waste, or have not been used on the scale necessary for the project, and some uncertainty will remain in these areas until the processes are more fully developed and tested. To account for these uncertainties, the assumptions in this HSW EIS are based on waste characterization and processing data that are intended to provide a conservative, or bounding, analysis of impacts for the alternatives under consideration. Previous evaluations of tank waste management alternatives indicated the long-term health risks from both radionuclides and chemicals in the waste were small and that concentrations of hazardous constituents in both groundwater and the Columbia River would meet federal drinking water standards (DOE 1987; DOE and Ecology 1996). Further evaluation of those risks is anticipated in the *Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site* (68 FR 1052).

3.5.4 Release, Fate, and Transport of Radioactive and Hazardous Materials

Estimating transport of hazardous materials or radionuclides through various environmental pathways to human or ecological receptors is a complex process, often requiring extensive input data. In order to predict the potential for future impacts, it is typically necessary to use computer models to simulate their transport and receptor exposure rates. Computer modeling may also be used to estimate the impacts from past releases where the quantity of released material is too small to measure in the field, or where contaminants arrive at the receptor location at very long times after the release occurs. The amount of data required for a particular simulation depends on the transport medium and exposure pathways of interest. The information needed to model transport through the environment may be relatively straightforward, such as measurements of wind direction and velocity, or highly complex, such as groundwater flow rates and directions. Likewise, exposure of receptors can depend on the behaviors of individuals or populations, such as food consumption rates.

With respect to long-term performance of disposal facilities, the transport of contaminants depends on performance of the waste form, factors affecting infiltration of water through the waste, and flow rates of groundwater, all of which are subject to substantial uncertainty over the long term. Contaminant release rates depend on treatment processes and the resulting physical and chemical characteristics of the waste form. For example, future decisions regarding the tank waste treatment process may affect the composition and long-term performance of the ILAW product, and some uncertainty will remain in these areas until the processes are more fully developed and tested. Performance of different ILAW waste forms is discussed briefly in Appendix G. Performance of the engineered disposal system, such as the use of greater confinement (HICs or trench grouting), trench liners, or infiltration barriers over the disposal facility is also difficult to predict over the very long time periods used for the analyses in performance assessments and in this EIS. Sensitivity analyses for barrier performance in the preferred alternative are presented in Appendix G. Other factors such as the geochemical environment, climate, and natural recharge rates in the future add to the uncertainty in predicting contaminant transport. In general, interactions among waste components that could change the geochemistry in the immediate vicinity of the disposal facility, such as the possible presence of organic chemicals in some previously disposed waste, are not expected to affect contaminant mobility over the long term. Such interactions would require relatively high concentrations of contaminants or large volumes of liquids to substantially influence contaminant mobility over the entire transport path. The solid wastes considered in this EIS would not contain large enough quantities of liquid organic chemicals or other potentially mobilizing agents to affect transport by this mechanism (See Appendix G).

After contaminants reach the accessible environment, potential impacts are controlled by the mechanisms that result in exposure to individuals or populations. A recent study of long-term transport of contaminants in groundwater indicated that, for estimates of human health effects, variability with regard to individual receptor behavior and exposure affects uncertainty in the result more than variability in inventory, release, or environmental transport of the contaminant. For example, uncertainties in estimates of near-term (present-day) risk to a hypothetical onsite resident farmer using tritium-contaminated groundwater downgradient from the 200 Area were dominated by uncertainties in the ingestion dose factor and by ingestion rates of contaminated food. Over the longer term (1,000 years), technetium-99 accounted for the largest share of risk to the onsite resident farmer from groundwater. At that time, parameters for transfer of technetium-99 to milk and vegetation, the technetium-99 ingestion dose factor, and technetium-99 ingestion rates for vegetables dominated the uncertainty. Estimates of release and transport accounted for a relatively small fraction (less than 15 percent) of the overall uncertainty in risk at either time (Bryce et al. 2002).

To account for these uncertainties, the assumptions in this EIS are based on waste characterization and processing data that are intended to provide a conservative, or bounding, analysis of impacts for the alternatives under consideration. Engineered systems are assumed to be effective for a reasonable but limited time compared with the period of analysis. Uncertainties associated with exposure parameters are typically addressed by using conservative assumptions in the model simulations, that is, assumptions that tend to maximize the exposure of individuals or populations to contaminants. An example is the use of atmospheric dispersion conditions that maximize the downwind concentrations of hazardous materials in accident simulations, as in the analyses reported in Section 5.11. In other cases, each parameter input to a simulation can be assigned a distribution of values, and multiple simulations can be run using randomly selected values for each parameter to obtain a distribution of outcomes associated with various probabilities. That approach was used to some extent for the cumulative groundwater impacts analysis described in Section 5.14 and Appendix L.

3.5.5 Human and Ecological Risk Associated with Exposure to Radioactive and Hazardous Materials

Human and ecological risk estimates are subject to many of the same uncertainties associated with fate and transport as described in the previous section. An added uncertainty is the inherent variability in biological and ecological systems, such as the genetic variation in populations that may predispose a particular individual to adverse health effects following exposure to a potentially hazardous material. Data on relative risks from hazardous material exposure are typically more difficult to obtain because of the ethical constraints on experimentation with human subjects. Extrapolating risk from animal studies to humans, or extrapolations of ecological impacts between different animal species, introduces additional uncertainty into the consequence estimates. As with the environmental transport calculations the approach used in the HSW EIS was to assign conservative values to most of the input parameters used in modeling risk from hazardous material exposures. For example, the estimates of potential cancer risk from exposure to radiation at very low doses, such as those from most environmental exposures, are based on data obtained at higher exposure rates and by different exposure pathways. The effect is assumed to be proportional to the dose received, although in the case of radiation, there is no experimental or epidemiological evidence that such effects occur at very low doses. The estimates of cancer incidence or fatality from very low radiation doses are therefore conservatively high, and encompass a range of possible risks that includes zero risk. Estimates of cancer risk in populations represent averages that account for the range in sensitivities of various members of the population, including children as well as adults.

In the HSW EIS analysis, exposure and risk parameters were generally set to reference values that have been widely adopted by regulatory agencies to establish environmental standards and to demonstrate compliance with those standards (such as the assumed consumption rate of 2 L/day used by EPA as the basis for setting standards for chemicals in public drinking water supplies). These reference parameter values are typically established to maximize the hypothetical risk that could occur to an individual who might be exposed via various pathways. This approach provides reasonable assurance that potential exposure to an actual individual would be unlikely to result in substantially greater risk. In any case, the comparison of impacts among the HSW EIS alternatives, and subsequent decisions based on the analyses, would not be affected by such assumptions because they are applied uniformly across all alternative groups.

3.5.6 Technical Maturity of Alternative Treatment Processes

Treatment technologies for most types of MLLW are specified by regulation. Where more than one technology might apply to a particular waste stream, a reference treatment technology was assumed for purposes of analysis. The consequences of waste treatment were typically estimated using conservative but realistic assumptions appropriate for the reference technology. For example, thermal treatment processes would be expected to result in greater emissions to the atmosphere than non-thermal technologies such as macroencapsulation. One uncertainty associated with MLLW treatment is the currently limited availability of thermal treatment processes for waste containing hazardous organic components. For purposes of analysis, this EIS assumed such treatment would be available at offsite commercial facilities within a reasonable time. However, an additional alternative was evaluated to consider the use of non-thermal options for those wastes in the event such treatment is not available.

With respect to ILAW, the reference treatment was assumed to be vitrification or another technology that produces a waste form having equivalent long-term performance. Other treatment technologies are currently under consideration for the low activity waste stream. Further evaluation of low activity waste treatment alternatives is anticipated in the *Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site* (68 FR 1052). Uncertainties associated with long-term performance of ILAW are addressed in this EIS by considering a range of performance characteristics for this waste stream (see Appendix G).

3.5.7 Timing of Activities Evaluated in the Alternative Groups

Under all HSW EIS alternative groups, there are uncertainties related to the timing of their implementation. Timing uncertainties include:

- the technical maturity of waste treatment technologies and the amount of development necessary before design and construction of facilities could proceed
- the possibility that regulatory requirements could change, which could introduce delays by affecting the design and cost of selected alternatives
- the time required to obtain necessary permits and approvals for various treatment, storage and disposal actions
- the timely appropriation of funds by Congress to enable DOE to implement decisions resulting from this EIS
- the effect of proposals for accelerated cleanup at Hanford (DOE-RL 2002) and at other DOE facilities, which could potentially influence the timing and quantities of waste receipts.

As discussed previously, these uncertainties are typically addressed in this EIS by adopting conservative assumptions in analyses (that is, assumptions that would tend to maximize the estimated environmental impacts). The timing of activities evaluated in the EIS may differ from assumptions used in the analyses; however, the nature and extent of those actions are expected to be similar whenever they may occur.

3.6 Costs of Alternatives

Consolidated cost estimates were prepared for the continued operation of existing facilities, the modification of existing facilities, construction of new facilities, and operation of the new or modified facilities (FH 2004; Aromi and Freeburg 2002). The costs were calculated using a constant 2002 dollars. Some operations, such as capping the LLBGs and treatment of leachate from mixed waste trenches, would continue beyond 2046. These costs have been included as a separate category. The cost of each major facility for each alternative group is shown in Table 3.21. The increased costs for the operation of the LLBGs with the increased volume of waste can be seen. Because the additional MLLW in the Upper Bound waste volume do not need treatment, the costs for treatment facilities do not change. In the No Action Alternative Group, the increased needs for storage of MLLW and the limited volume of waste disposed of are reflected in the relative costs of the CWC and the MLLW trenches. The increased costs for the baseline operation of the T Plant Complex for the No Action Alternative Group compared with Alternative Groups A, B, and C result from the continuing need to store the K Basin sludge in the No Action Alternative. The combination of commercial MLLW treatment and modification of the T Plant Complex in Alternative Group A is less expensive than construction of a new facility, with DOE doing the majority of the treatment onsite in Alternative Group B. The consolidation of disposal facilities should lead to lower disposal costs – most easily noted in the total alternative group costs between Alternative Groups D and E and Alternative Group A.

Table 3.21 (sheet 1). Consolidated Cost Estimates for Alternative Groups A, B, and C (Construction and Operation Cost)

	Cost of Alternatives (Millions of Dollars)								
	Group A			Group B			Group C		
	Waste Volume			Waste Volume			Waste Volume		
Cost Category	Hanford Only	Lower Bound	Upper Bound	Hanford Only	Lower Bound	Upper Bound	Hanford Only	Lower Bound	Upper Bound
LLBGs	267	339	484	268	340	485	267	339	484
CWC	566	566	566	566	566	566	566	566	566
WRAP	710	710	710	710	710	710	710	710	710
T Plant	376	376	376	376	376	376	376	376	376
Commercial MLLW Treatment	229	229	229	17	17	17	229	229	229
New Treatment Capacity	457	457	457	830	830	830	457	457	457
MLLW and Melter Disposal	275	275	424	268	268	429	275	275	424
ILAW Disposal	680	680	680	680	680	680	506	506	506
Post 2046 Costs	103	103	116	110	110	125	103	103	116
Total Operations	3663	3735	4042	3825	3897	4218	3489	3561	3868
Post-Operational Monitoring	75	75	75	75	75	75	75	75	75

Table 3.21 (sheet 2). Consolidated Cost Estimates for Alternative Groups D, E, and No Action

Cost Category	Cost of Alternatives (Millions of Dollars)							
	Groups D1, D2, and D3			Groups E1, E2, and E3			No Action[b]	
	Waste Volume			Waste Volume			Waste Volume	
	Hanford Only	Lower Bound	Upper Bound	Hanford Only	Lower Bound	Upper Bound	Hanford Only	Lower Bound
LLBGs	(a)	(a)	(a)	(a)	(a)	(a)	268	345
CWC	566	566	566	566	566	566	1090	1090
WRAP	710	710	710	710	710	710	710	710
T Plant	376	376	376	376	376	376	511	511
Commercial MLLW Treatment	229	229	229	229	229	229	17	17
New Treatment Capacity	457	457	457	457	457	457	0	0
MLLW and Melter Disposal	755	777	1076	486	511	829	152	152
ILAW Disposal	(a)	(a)	(a)	506	506	506	706	706
Post 2046 Costs	103	103	116	103	103	116	(b)	(b)
Total Operations	3196	3218	3530	3433	3458	3789	3454	3531
Post-Operational Monitoring[c]	75	75	75	75	75	75	75	75

(a) Combined disposal facility – costs included in MLLW and melter disposal.
(b) Does not account for costs for storage, treatment, or eventual disposal of waste remaining in storage after 2046.
(c) Estimated minimum cost of $500,000 per year for a 100-year institutional control period (DOE 2002). Maximum cost estimated at $750,000 per year depending on number of wells and monitoring requirements.

3.7 DOE Preferred Alternative

Based on the results of the environmental consequences analyses (as presented in Section 5 and summarized in Section 3.4), cost, and other considerations, DOE has identified its preferred alternative for the HSW EIS. The preferred alternative consists of those actions identified in Alternative Group D_1. The preferred alternative would be implemented for Hanford and offsite waste up to the Upper Bound volume. Offsite waste would be managed in the same manner as onsite waste. The preferred alternative would be implemented as follows:

Storage: The Central Waste Complex will continue to be the primary storage facility for LLW, MLLW, and TRU waste. Consistent with previous decisions, TRU waste retrievably stored in the Low Level Burial Grounds would be retrieved for processing and shipment to WIPP. Until the waste is retrieved, it would continue to be stored in the LLBGs. Newly generated mixed TRU waste from onsite and offsite generators would be stored in RCRA-compliant storage facilities such as CWC and T Plant. Newly generated non-mixed TRU waste from onsite and offsite generators would be stored in several places, such as CWC and T Plant, but remote-handled waste could be stored temporarily in the Low Level Burial Grounds. T Plant would be used to store sludge from the K Basins.

Treatment: LLW and MLLW would be treated using a combination of existing capabilities and processes, offsite commercial capabilities, and a modified T Plant. TRU waste would be processed and certified using a combination of the Waste Receiving and Processing Facility, a modified T Plant, and mobile processing facilities (APLs).

Disposal: Newly generated LLW, MLLW, ILAW, and WTP melters would be disposed of in a new modular facility near PUREX. This new disposal facility would include a RCRA-compliant liner and a leachate collection/leak detection system. Upon closure, it would be capped with a Modified RCRA Subtitle C Barrier. Waste previously disposed of in the Low Level Burial Grounds would be similarly capped. Existing disposal capacity in the Low Level Burial Grounds would continue to be used as necessary to meet short-term requirements pending construction and operation of the new disposal facility.

In general, waste management activities outlined in Alternative Group D_1 would be operationally efficient, cost-effective, and environmentally preferable as to many types of potential impacts. The differences in impacts among all alternative groups would be relatively minor. However, Alternative Group D_1 appears to offer a combination of low environmental impacts and low cost. Future waste disposal operations would be combined in a single location that could provide a more unified regulatory pathway to construction, operation, and stewardship.

3.8 References

40 CFR 141. "National Primary Drinking Water Regulations." Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfr141_01.html

40 CFR 1500-1508. "Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act." Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfrv28_01.html

46 FR 18026. "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations: 1. Range of Alternatives." March 23, 1981. Online at: http://ceq.eh.doe.gov/nepa/regs/40/40p3.htm

64 FR 61615. "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)." *Federal Register* (November 12, 1999). Online at: http://www.gpoaccess.gov/fr/index.html

65 FR 10061. "Record of Decision for the Department of Energy's Waste Management Program: Treatment and Disposal of Low-Level Waste and Mixed Low-Level Waste; Amendment of the Record of Decision for the Nevada Test Site." *Federal Register* (February 25, 2000). Online at: http://www.gpoaccess.gov/fr/index.html

68 FR 1052. "Notice of Intent to Prepare an Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington." *Federal Register* (January 8, 2003). Online at: http://www.gpoaccess.gov/fr/index.html

Aromi, E. S. and R. D. Freeberg. 2002. *Request for CHG Support Concerning Immobilized Low-Activity Waste Choices*. CHG-0203620R2, CH2M Hill Hanford Group, Richland, Washington.

Bryce, R. W., C. T. Kincaid, P. W. Eslinger, and L. F. Morasch (eds.). 2002. *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*. PNNL-14027, Pacific Northwest National Laboratory, Richland, Washington. Online at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14027/PNNL-14027.pdf

Burbank, D. A. 2002. *Conceptual Design Report for Immobilized Low-Activity Waste Disposal Facility, Project W-52 Rev 0*. RPP-7908, Rev. 0A, CH2M Hill Hanford Group, Richland, Washington.

DOE. 1985. *Volume II RCRA Part B Permit Application Low-Level Burial Grounds and Retrievable Storage*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://www2.hanford.gov/ARPIR/common/findpage.cfm?AKey=D196004062

DOE. 1987. *Final Environmental Impact Statement for Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes*. DOE/EIS-0113, U.S. Department of Energy, Washington D.C.

DOE. 1993. *Radiation Protection of the Public and the Environment*. DOE Order 5400.5, U.S. Department of Energy, Washington, D.C. Online at: http://www.directives.doe.gov

DOE. 1996. *Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan*. DOE/EIS-0222D, U.S. Department of Energy, Washington, D.C.

DOE. 1997a. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*. DOE/EIS-0200-F, Vol. 1-5, U.S. Department of Energy, Washington, D.C.

DOE. 1997b. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*. DOE/EIS-0026-S-2, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.

DOE. 2002. *Report to Congress – The Cost of Waste Disposal: Life Cycle Cost Analysis of Disposal of Department of Energy Low-Level Radioactive Waste at Federal and Commercial Facilities*. U.S. Department of Energy, Office of Environmental Management, Washington, D.C. Online at: http://www.envirocareutah.com/pages/pdf/Final_LLW_Report_7_08_02.pdf

DOE-RL. 1989. *Low-Level Burial Grounds Dangerous Waste Permit Application*. DOE/RL-88-20, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL. 2002. *Performance Management Plan for the Accelerated Cleanup of the Hanford Site*. DOE/RL-2002-47, Rev. D, U.S. Department of Energy Richland Operations Office, Richland, Washington. Online at http://www.hanford.gov/docs/rl-2002-47/rl-2002-47.pdf

DOE and Ecology. 1996. *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement.* DOE/EIS-0189, U.S. Department of Energy, Richland, Washington and Washington State Department of Ecology, Olympia, Washington.

Eckerman, K. F. and J. C. Ryman. 1993. *External Exposure to Radionuclides in Air, Water, and Soil, Federal Guidance Report No. 12*. EPA 402-R-93-081, U.S. Environmental Protection Agency, Washington, D.C.

Eckerman, K. F., A. B. Wolbarst, and A. C. B. Richardson. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Federal Guidance Report No. 11*. EPA-520/1-88-020, U.S. Environmental Protection Agency, Washington, D.C.

FH. 2003. *Hanford Site Solid Waste Acceptance Criteria*. HNF-EP-0063, Rev. 9, Fluor Hanford, Inc., Richland, Washington. Online at: http://www.hanford.gov/wastemgt/wac/acceptcriteria.cfm

FH. 2004. *Hanford Site Solid Waste Management Environmental Impact Statement Technical Information Document*. HNF-4755, Rev. 2, Fluor Hanford, Inc., Richland, Washington.

Hanford Advisory Board. 1997. *Framing of Issues Disposition of Canyon Facilities Prepared by EnviroIssues for Hanford Advisory Board*. July 11, 1997. Online at: http://www.hanford.gov/boards/hab/letters/97-016a.htm

Hartman, M. J., L. F. Morasch, and W. D. Webber, eds. 2002. *Hanford Site Groundwater Monitoring for Fiscal Year 2001*. PNNL-13788, Pacific Northwest National Laboratory, Richland, Washington. Online at: http://groundwater.pnl.gov/reports/gwrep01/start.htm

NCRP. 1996. *A Guide for Uncertainty Analysis in Dose and Risk Assessments Related to Environmental Contamination*. NCRP Commentary No. 14, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

Poston, T. M., R. W. Hanf, R. L. Dirkes, and L. F. Morasch (eds.). 2002. *Hanford Site Environmental Report for Calendar Year 2001.* PNNL-13910, Pacific Northwest National Laboratory, Richland, Washington. Online at: http://hanford-site.pnl.gov/envreport/2001/index.htm

Richland Environmental Restoration Project. 2001. *Canyon Disposition Initiative Project*. Online at: http://www.bhi-erc.com/projects/s_m/cdi/cdi.htm

WDOH and Ecology. 2000. *Draft Environmental Impact Statement. Commercial Low-Level Radioactive Waste Disposal Site, Richland, Washington*. Washington State Department of Health and Washington State Department of Ecology, Olympia, Washington. Online at: http://www.ecy.wa.gov/pubs/0005010.pdf